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SPACE TUG SYSTEMS STUDY (CRYOGENIC) SEPTEMBER DATA DUMP

VOLUME 4 Mission Accomplishment **Book 1 Option 1**

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PREPARED BY: SPACE TUG STUDY TEAM

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PREPARED FOR NATIONAL AERONAUTICS AND SPACE ADMINISTRATION MARSHALL SPACE FLIGHT CENTER **UNDER CONTRACT NO. NAS8-29677**

PREFACE

This study report for the Tug Program is submitted by the McDonnell Douglas Astronautics Company (MDAC) to the Government in partial response to Contract Number HAS8-29677.

The current results of this study contract are reported in eight volumes:

Volume 1 - Summary, Program Option 1

Volume 2 - Summary, Program Option 2

Volume 3 - Summary, Program Option 3

These three summary volumes present the highlights of the comprehensive data base generated by MDAC for evaluating each of the three program options. Each volume summarizes the applicable option configuration definition, Tug performance and capabilities, orbital and ground operations, programmatic and cost considerations, and sensitivity studies. The material contained in these three volumes is further summarized in the Data Dump Overview Briefing Manual.

This volume contains mission accomplishment analysis for each of the three program options and includes the tug system performance, mission capture, and fleet size analysis.

Volume 5 - Systems (3 Books)

This volume presents the indepth design, analysis, trade study, and sensitivity technical data for each of the configuration options and each of the Tug systems i.e., structures, thermal, avionics, and propulsion. Interface with the Shuttle and Tug payloads for each of the three options is defined.

Volume 6 - Operations (3 Books)

This volume presents the results of orbital and ground operations trades and optimization studies for each option in the form of operations descriptions, time lines, support requirements (GSE, manpower, networks, etc.), and resultant costs.

Volume 7 - Safety (3 Books)

This volume contains safety information and data for the Tug Program. Specific safety design criteria applicable to each option are determined and potential safety hazards common to all options are identified.

Volume 8 - Programmatics and Cost (3 Books)
This volume contains summary material on Tug Program manufacture, facilities,
vehicle test, schedules, cost, project management SR&T, and risk assessment for
each option studied.

These volumes contain the data required for the three options which were selected by the Government for this part of the study and are defined as:

- A. Option 1 is a direct development program (I.O.C.: Dec 1979). It emphasizes low DDT&E cost; the deployment requirement is 3500 pounds into geosynchronous orbit, it does not have retrieval capability, and it is designed for a 36-hour mission. MDAC has also prepared data for an alternative to Option 1 which deviates from certain requirements to achieve the lowest practicable DDT&E cost.
- B. Option 2 is also a direct development program (I.O.C.: 1983). It emphasizes total program cost effectiveness in addition to low DDT&E cost. The deployment requirement is 3500 pounds minimum into geosynchronous orbit and 3500 pounds minimum retrieval from geosynchronous orbit.
- C. Option 3 is a phased development program (I.O.C.: 1979 phased to I.O.C. 1983). It emphasizes minimum initial DDT&E cost and low total program cost. The initial Tug capability will deploy a minimum of

3500 pounds into geosynchronous orbit without retrieval capability, however, through phased development, it will acquire the added capability to retrieve 2200 pounds from geosynchronous orbit. The impact of increasing the retrieval capability to 3500 pounds is also provided.

INTRODUCTION

This volume contains the results of the mission accomplishment assessment analysis for program options 1, 2, and 3, the increased retrieval capability (called 3S), and the other sensitivity studies which impact mission accomplishment. The volume is divided into three books, one for each of the major options (1, 2, and 3), and a supplement for the increased retrieval version of option 3—identified as 3S. Sensitivity impacts are included with the option to which they are addressed. Each includes identification of vehicle concept and its related performance, a summary of the capture analysis and the flight by flight mission assignments.

The data presented in this volume conforms to the agreements and groundrules provided at the August 6, 1973 Mission Model Standardization Meeting at Denver, Colorado. The forms provided at that meeting and subsequently transmitted by NASA letter PD-TUG-E (74-49) are included in the data provided. To provide a complete compilation of the data, the Government provided mission model for each option is included.

The capture analysis was performed by selecting payloads for each Tug flight based upon the inherent performance capability of the Tug (payload weight vs. delta velocity, mission duration, maneuver, rendezvous and docking and multi-payload), the constraints of the Shuttle (payload weight vs. orbit and cargo bay physical dimension) and the characteristics of the payload (physical size, weight, Tug mission required). Payloads were combined to provide the least total flights to accomplish the mission model requirements.

GROUNDRULES

The Mission Capture Analysis was constrained by the ground rules provided by the Government and by the characteristics of each of the programs. The ground rules used were as follows:

- 1. All missions are to be accomplished for each configuration(s) in each option according to the deploy/retrieve schedule and payload weights specified in the Option Mission Model.
- 2. The additional payload capture potential for each configuration to perform those mission excluded from the Option Mission Model because of performance and/or Tug mission duration constraint assumed for the basic option will be assessed. This assessment is to identify the additional payload missions that could be performed, the Tug flight configuration and mode required, and the total number of payloads that could be accommodated.
- 3. DOD Mission 11 has been excluded from Option 1 because of the mission duration impact on the Tug.
- 4. DOD Mission 12 is defined as a sortic mission having a nominal mission duration of seven days; however, for the capture analysis it is to be assumed that the mission duration inherent in the Tug configuration for the Option being considered is sufficient; therefore mission duration is not be be considered in determining the capture potential of this mission but performance capability only.
- 5. DOD Mission 12b weight is to be assumed fixed at 2400, and not "rubber" as footnoted in Table A-3 of the DOD Mission Model Annex.
- 6. The current design weight is to be assumed for all planetary deployments in the basic option mission models.

- 7. For Option 1 the Tug provides no capability for longitudinal positioning of payloads after attaining sync orbit, but for Option 2 and 3 the Tug provides a one-time 60° longitude shift capability for multi-deploy missions. The payload is assumed to have on-board capability for any additional maneuvers required for final positioning (see previously provided Government Action Item for more detail).
- 8. NASA Geo Sync payloads may be combined for deployment up to a total of three payloads for a single Tug flight.
- 9. DOD 3a may be deployed as a single payload or as a two payload combination. The payload provides orbit positioning capability. Round-trip missions should assume 1 payload deployed/1 payload retrieved.
- 10. DOD 11 payloads provide orbit positioning.
- 11. NASA payloads 12-16 may be combined for deployment with the Tug providing the energy for orbit changes only with no requirement for payload positioning within the orbit.
- 12. Single payload retrieval missions are to be assumed in all cases.
- 13. Planetary payloads (NASA Missions 17 through 24) are always single deployment missions.
- 14. The contractor is to determine the most cost effective mode for mission accomplishment (i.e., expend vs. orbit assembly, etc.).
- 15. In Options 2 and 3 LCD and CD payload may be combined for deployment.
- 16. For configurations employing the "nudge" mode the DOD groundrule of not mixing payloads on a given flight is to be adhered to, i.e., only the same type payload may be deployed and "nudged" on the same flight.

- 17. The 300 watt power supply to the payload is not a requirement for Option 1, and for Options 2 and 3 it may be assumed that a total of 300 watts is constant and continuous until the last payload is deployed and is not a function of the number of payload in a multi-deploy mission.
- 18. Payloads may be physically combined in any orientation such that the Shuttle cargo bay boundaries (15' \times 60') are not violated.

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Section 1

PERFORMANCE

1.1 PERFORMANCE GROUND RULES

The payload performance was determined using the classical impulsive velocity equation. The velocities employed were based on the three dimensional finite burning trajectory analyses performed during Task 1. A detailed simulation of the basic geosynchronous deployment mission taking into account the actual losses associated with each engine start and the velocity contributed by propellant settling forces was used to determine an equivalent specific impulse penalty of 4 seconds which was then used for all missions.

For the geosynchronous transfer, a velocity of 13972 fps was used which represents the most unfavorable situation (from a performance point of view) of no low orbit phasing being required and the resulting injection to the transfer orbit being performed with only one burn instead of two. This velocity is approximately 80 fps greater than the most favorable two burn transfer injection. The 36 hour maximum mission duration for this option does not permit the long phasing required to reach particular longitudes with the two burn departure. For the return, a velocity of 13920 fps was used.

The following weights and engine data were also employed in the performance computations:

Shuttle Capability	65,000
Ancillary equipment (to install Tug in the Orbiter Bay)	2,066
Vented during ascent	269
Tug gross weight at deployment from Orbiter Bay	62,665
Tug burnout weight (includes FPR)	7,340
Propellant capacity (@5.5 EMR)	51,000

Engine chilldown (each start)	61
Vented in flight	57
Attitude control propellant	93
Propellant settling	160
Engine	Category I RL-10
Thrust	15,000
Isp (@ 5.5EMR)	441.8

1.2 GEOSYNCHRONOUS PERFORMANCE

Based on the foregoing ground rules and data, it was determined that Option 1 could deploy 3521 lb to a geosynchronous orbit. This option has no requirement for retrieval capability, consequently the tankage was sized for the deployment missions. As a result, the propellant tanks rather than Shuttle delivery (and consequently Tug gross weight) become the limiting factor in round trip mission performance. The resultant round trip payload capability is 993 lb. It must be pointed out that this round trip mission involves carrying a single payload to synchronous orbit and returning with it rather than delivering one payload and retrieving of a second of equivalent weight. Figure 1.2-1 shows how the payload delivery capability decreases as payload is returned.

1.3 PERFORMANCE ENVELOPE - PAYLOAD WEIGHT vs. A VELOCITY

Figure 1.3-1 presents the payload velocity envelope for the mission modes applicable to Option 1 for due east Shuttle launches. The following figures show the same data for Shuttle launches into 55° and polar inclinations. These data reflect the 4 second Isp penalty for stop/start losses, boiloff and attitude control propellants. For missions where the Tug would be less than fully loaded, it would be advantageous to off load LOX only initially to reduce the engine mixture ratio and improve Isp by up to 4 seconds at the limiting EMR of 4.5:1.

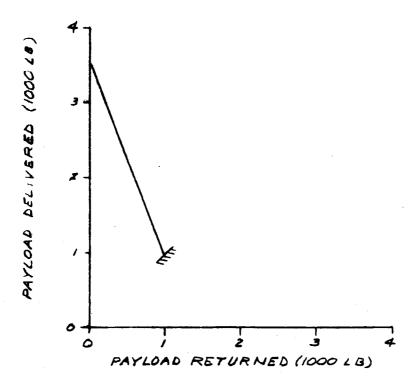
1.4 PERFORMANCE SENSITIVITIES

1.4.1 General Mission Trade Factors

The sensitivity of payload to the two principle performance factors, -Tug inert weight and Isp - are presented as a function of mission velocity in Figure 1.4-1.

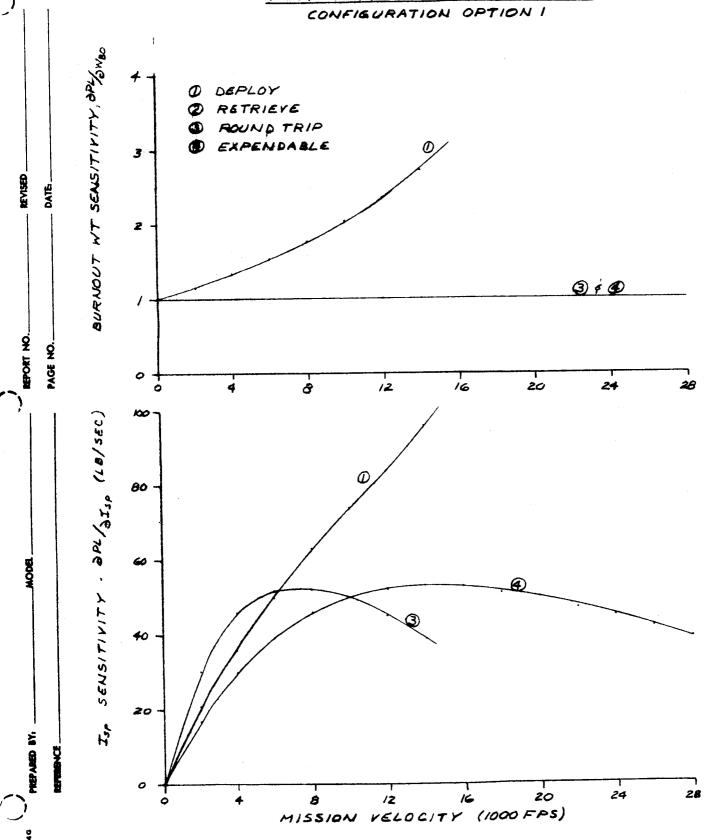
GEOSYNCHRONOUS PERFORMANCE CONFIGURATION OPTION I

NOTE: PAYLOAD RETURNED IS INCLUDED AS PART OF PAYLOAD DELIVERED .





PERFORMANCE SENSITIVITY



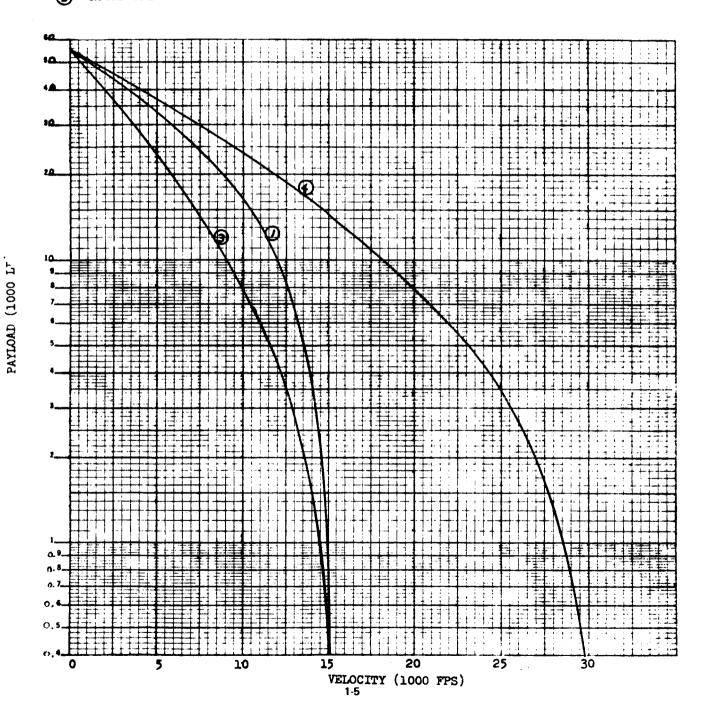
PERFORMANCE CAPABILITY

CONFIGURATION OPT

- I_{SP} 441.8 INCL 28.5° (4) EXPENDABLE

1 DEPLOY

- RETRIEVE
- ROUND TRIP



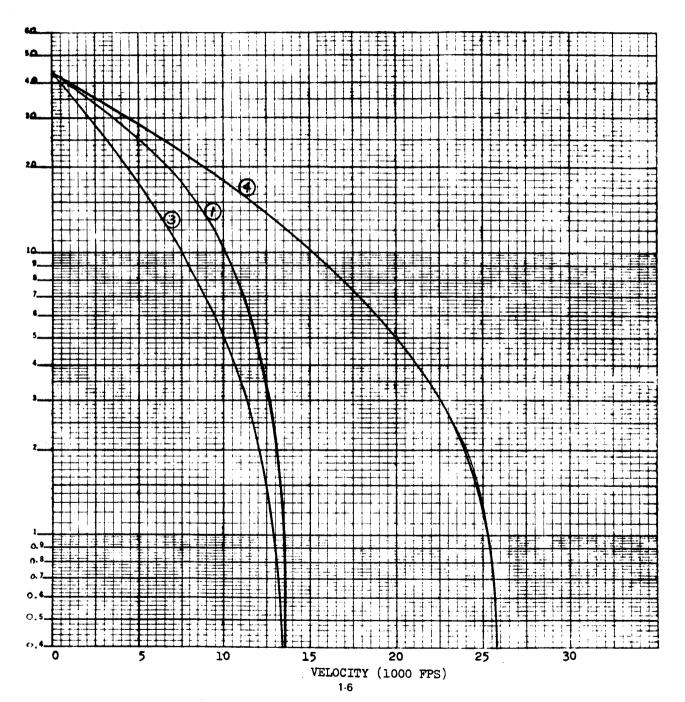
PERFORMANCE CAPABILITY

CONFIGURATION OPT /

 $V_{BO} = \frac{7340}{1_{SP}}$ $V_{AB} = \frac{441.8}{1_{NCL}}$ $V_{AB} = \frac{55^{\circ}}{4_{AB}}$ $V_{AB} = \frac{55^{\circ}}{4_{AB}}$



- 2 RETRIEVE
- 3 ROUND TRIP



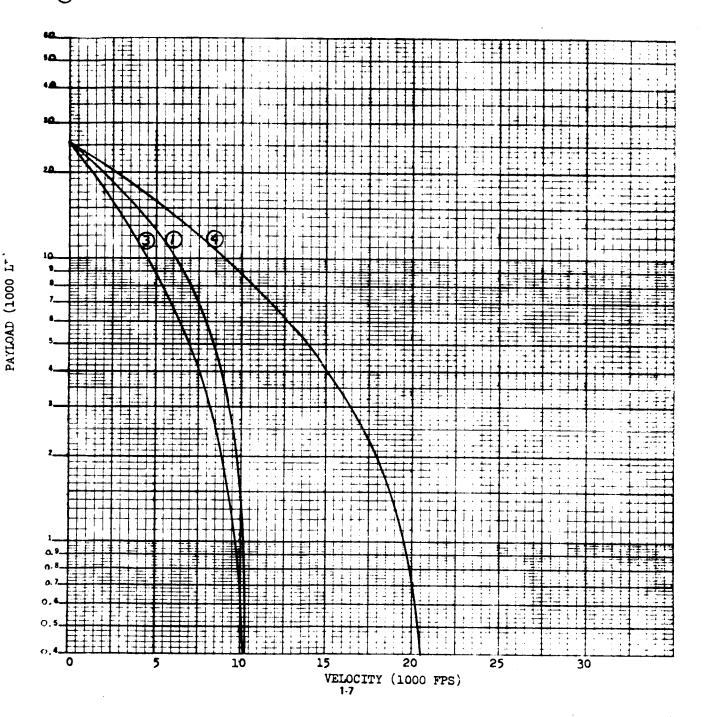
PERFORMANCE CAPABILITY

CONFIGURATION OPT /

(4) EXPENDABLE

I_{SP} 4418 I_{MCL} 90°

- (1) DEPLOY
- (2) RETRIEVE
- (3) ROUND TRIP



1.4.2 Geosynchronous Trade Factors

Specific trade factors for the geosynchronous missions are given in Table 1.4-1. The inert weight factor is applicable to any weight carried throughout the mission, such as structure and residual propellants. The gross weight factor can correct for variations in the Tug gross weight at first ignition such as Shuttle capability, ancillary equipment or propellants vented during ascent.

1.5 MISSION PERFORMANCE

The performance capability for each mission in the mission model was computed for each basic mission mode. The missions are defined in Table 1.5-1. Table 1.5-2 is a computer printout of the results and includes the velocities derived from Task I. The gross weight reflects the Shuttle delivery capability to the appropriate parking orbit inclinations. In several cases, alternate mission profiles are shown starting from different inclinations.

For the Option 1 vehicle, retrieval capabilities are shown even though the equipment necessary to physically pick up or attach such a payload is not included in the Tug weight shown. The capabilities with a kick stage were also determined for use in the mission capture analysis but are not shown simply to avoid classifying any data.

Several missions with gross weights of 62,665 show payloads below the nominal geosynchronous deployment capability of 3,932. For these specific missions, the propellant burned would exceed the capacity of the tanks. The following formula should be used to provide an approximate corrected payload reflecting the propellant tank limitations:

PL_{Corrected} = PL_{Shown} - (3.932-PL_{Shown})
$$\frac{\partial PL}{\partial w}$$
.

Table 1.4-1
GEOSYNCHRONOUS MISSION TRADE FACTORS

	DEPLOY	ROUND TRIP
Burnout Weight: ^{3PL} / _{3WBO}	-2.67	-1
Specific Impulse: ^{OPL} /OI _{sp}	95	39
Gross Weight: PL/OWO	.37	.14
Orbit Losses: ^{3PL} / _{3WOL}	-1	37

Table 1.5-1
MISSION DESCRIPTIONS

Mission No.	Hax Hp (nmi)	Incl.	Remarks
1-8	19323	0	Synchronous orbit - single burn transfer orbit injection
1-8A	19323	0	Synchronous orbit - two burn transfer injection
1 - 8B	19323	0	Synchronous orbit - two burn transfer injection with 600 fps for multiple payload deployments
9	la u	Eclip.	
10	6 90 0	55°	
10A	6900	55 °	Alternate - Shuttle launched into 28.5°
11	16K×30K	20 °	
12	180x1800	90°	
13	1Kx20K	90°	
13A	1Kx20K	90 °	ETR Alternate - Shuttle launched into 28.5°
13B	1Kx20K	90 °	ETR Alternate - Shuttle launched into 55°
14	300x3000	90 °	
15	700	100°	
16	500	99.2°	
17-8	Interplan	etary	ΔV - 13000
19			16500
20			23000
21-2			24000
23			18400
24			22000
D11	58 K	0,30,60	
D10	860x21K	63.4	Shuttle launch into 63.4° WTR
DloA	860x21K	63.4	ETR Alternate - Shuttle launched into 55°
D 5	7 50	99 °	
D3	13.6Kx25K	60 °	Shuttle launched into 60° WTR
D3A	13.6x25K	60 °	ETR Alternate - Shuttle launched into 55°
D12	300	1040	
D16	400	98.3°	

CØNFIGUR	ATION OPT 1	STAGE WT	=7340.00 IS	SP=441.80 DE	LISP=4.00
MISSIØN	GRØSS-WT V-ØUT	PL-RØUND V-BACK	PL-DEPLØY	PL-RETRI EV	E PL-EXPEND
1-8	62665.00	993,00	3521.35	2087.99	15900-11
	13972.00	13920.00			
1-8A	62665.00 13890.00	1361•27 13920•00	3657.04	2168 • 44	16035.79
1-8B	62665.00 14190.00	998 • 42 1 4220 • 00	2739.99	1570.82	15543.22
9	62665.00 14160.00	939•44 14350•00	2602.03	1470.28	15592.01
10	50665.00	5440.99	10833.03	10931.39	18106.98
	9700.00	9700.00			
10A	62665.00 12760.00	2897 .37 12760 . 00	7168 • 42	4862.89	17988.35
11	62665.00	3358.05	8127.34	5722.47	18551.96
	12450.00	12450.00			
12	32665.00 2285.00	16274.57 2285.00	19140.84	108 68 1 - 37	20433.55
13	32665.00 8400.00	2570•66 8400•00	4666-97	5723.02	10652.55
13A	62665.00 13460.00	1928 •80 13460 •00	5015.20	3134.18	16760.40
13B	50665.00 11200.00	2989 • 24 11200 • 00	6620•35	5450.08	15536•43
14	32665.00 3600.00	12252.56 3600.00	15820•59	54327.76	17958.04
15	26665.00 1700.00	13606.58 1700.00	15351-94	119681.69	16293.46
16	26665.00 1120.00	15404.58 1120.00	1 6679 • 45	201542.69	17286-90
17-8	62665.00 13140.00	228 4 • 20 13250 • 00	58 51 • 40	3746.85	17314.18
19	62665.00 16740.00	.00 17210.00	•00	•00	11753.93
20	62665.00 23550.00	•00 24500•00	•00	•00	4434.11

21-2	62665•00 24600•00	.00 25500.00	•00	•00	3588.35
23	62665.00 18720.00	•00 19550•00	•00	•00	9250.04
24	62665•00 22500•00	.00 23500.00	•00	•00	5345•34
D11	62665•00 13930•00	1330•44 13930•00	3576.74	2118.43	15969.50
D10	48 665•00 8 500•00	7216•95 8500•00	13195•53	15928•77	19276.04
DIOA	50665•00 9800•00	5260.80 9800.00	10548.90	10494•46	17926•97
D5	26665•00 1770•00	13399 • 42 1770 • 00	15193•52	113474.25	16176•30
D3	48 665 • 00 1 18 50 • 00	1706•80 11850•00	39 58 • 64	3000•51	13642•44
D3A	50665.00 11920.00	1985•46 11920•00	4627.86	3477.30	14396•47
D12	26665.00 500.00	17497•61 500•00	18129 •87	501743.19	18395•09
D16	26665•00 850•00	16293•48 850•00	17306.96	278240.25	17763 • 52

Section 2

CAPTURE ANALYSIS - OPTION 1

2.1 Flight Summary

The data provided in Section 2.1.1 represents a summary of the missions captured by the Option 1 program based upon all constraints of the system potential (Tug capability) and the program schedule (Tug and related support systems availability). Section 2.1.2 identifies the missions, from the Option Mission Model, which are not captured by the program and also includes the rationale for their exclusion.

2.1.1 Flight Summary Data

Tables 2-1 through 2-5 present the number of flights per year for each of the flight modes used in Option 1. Also shown are the total Shuttle and Tug flights and the number of missions identified as requirements in the Option Mission Model. On Table 2-1 the number of missions accomplished is identified.

The mission modes used in this option are defined as follows:

Deploy

- Single Payload The deployment of one payload to one location and velocity vector and return of the Tug to the Shuttle.
- Multi 2 Payloads the deployment of two payloads to one location and velocity vector and return of the Tug to the Shuttle.
- Multi 3 Payloads the deployment of three payloads to one location and velocity vector and return to the Shuttle.
- Kick Stage Large the deployment of one or more payloads to one location and velocity vector using a Polaris kick stage as a second stage to the Tug. The kick stage is expended and the Tug returns to the Shuttle.
- Expendable the deployment of one payload to one location and velocity vector.

 The Tug is expended.

Round-Trip

Sortie - Carrying a payload to one orbital location remaining in that location for 22 hours and returning the Tug and the payload to the Shuttle.

Total ∞ 34/ <u>--</u> a Н <u>~</u> $^{\circ}$ ~ ľ \sim N α \vdash Calendar Year \sim $^{\circ}$ **_** -4 Q Н N \sim \vdash Н Q \vdash Н \sim $^{\circ}$ S H \Box Large Multi--2 Payloads Multi--3 Payloads Single Payload Total Kick-Stage Round Trip Expendable Flight Mode Retrieve Retrieve Shuttle Sortie Deploy Deploy Total Total \mathbf{T} u \mathbf{g} FLIGHT SUMMARY-OPTION 1 Accomplishment Mission Model Distribution Totals Tug Flight

FLIGHT SUMMARY-NASA-OPTION 1

			-			Calendar	t .	Year					
F4	Flight Mode	80	81	82	83	48	85	98	87	88	99	96	Total
	Shuttle	3	8	8	14	17	12	10	16	6	17	6	120
Totals	Tug	3	8	8	17	7,7	12	10	16	0	17	σ	120
	Deploy)
	Single Payload	2	4	3	7	7	9	2	9	7	7	~	52
	Multi2 Payloads			2	5	m	2	2	9	-	ıc	7	30
	Multi3 Payloads	Н	†	1	7		7	2	7	~	2	-	2
	Kick-Stage Mode			2		2		·m	2				0
Tug	Expendable					2			-		~	-	α
Flight Distribution											1		
	Retrieve												
	Single Payload												
	Round Trip												
	Deploy 1/Retrieve 1												
	Deploy Multi/Retrieve l		· .										
	Sortie								<u> </u>				
	Total												
	Deploy	17	16	12	23	17	22	16	77	16	56	15	201
Mission Model	Retrieve	0	0	0	0	0	0	0	0	0	0	0	0
									1				A

FLIGHT SUMMARY-DOD-OPTION 1

						Calendar	i	Year					
Ę	Flight Mode	80	81	82	83	78	85	98	87	88	99	66	Total
	Shuttle	0	9	6	15	12	10	10	12	11	10	11	106
Totals	Tug	0	9	6	15	12	10	10	12	11	10	11	106
	Deploy												
	Single Payload		2	9	8	8	7	5	7	7	9	7	99
	, ,			m	5	Ж	2	7	3	-1	2	3	30
	Pavloa					-1		7	Н		ч	П	9
	Mode							·					
	NICA-Orage Mode								-				
Tug	Expendabl.e												
Flight													
Distribution	Retrieve												
	Single Payload												
	i												
	Round Trip												
	Derloy 1/Retrieve 1												
	Deploy Multi/Retrieve 1												
	Sortie				г		1		П,		7		4
	Total												
	Devloy	11	2	12	22	17	12	16	17	15	17	16	159
Mission Model	Retrieve	0	0	0	Τ	0		0		0	П	0	.⇒
		7											

FLIGHT SUMMARY-ETR-OPTION 1

Tright Mode 86 81 82 84 84 85 87 88 89 90 Total This condition Model 80 81 82 84 84 85 87 88 89 90 Total Shuttle Payload 25 29 15 15 13 12 13 10 118 Milti2 Payloads 1 4 1 2 2 2 1 3 1 3 1 1 1 5 1 1 1 1 1 1 1 1 1 1 1 1							Calendar	1 1	Year					
Shuttle	Ξ4	light Mode	80	81	82	83	84	85	98	87	88	89	96	Total
Tug		Shuttle	3	14	16	22	24	17	17	24	18	20	18	193
Deploy Single Payload Single Payload Single Payloads In the Trieve Single Payload Single Payload Single Payload Single Payload Sortie Total Deploy Multi/Retrieve I Sortie Total Deplo	Totals	Tug	3	14	16	22	7p	17	17	77	18	20	18	193
Single Payloads 2 9 15 15 13 7 13 12 13 10 Multi2 Payloads 1 4 1 5 2 4 7 3 4 6 Kick-Stage Mode 1 4 1 2 2 3 2 1 3 1 Expendable 2 2 2 3 2 3 2 1 1 3 1 Expendable 2 2 2 3 2 3 2 1 1 3 1 Expendable 3 4 4 1 2 2 3 2 2 1 1 3 1 1 Single Payload 3 4		Deploy												
whiti2 Payloads 1 4 7 5 2 4 7 3 4 6 4 Multi3 Payloads 1 4 1 2 2 1 3 4 1 1 1 3 4 6 4 Kick-Stage Mode 1 2 2 2 1 3 2 1 3 1		Single Payload	2	6	6	15	15	13	7	13	12	13	10	118
Wilti3 Payloads 1 4 1 2 2 2 2 1 3 1 Expendable 2 2 2 3 2 3 2 1 1 3 1 1 1 3 1 1 1 3 1 </td <td></td> <td></td> <td></td> <td>1</td> <td>tr</td> <td>7</td> <td>5</td> <td>2</td> <td>4</td> <td>7</td> <td>3</td> <td><i>\</i></td> <td>9</td> <td>F†</td>				1	tr	7	5	2	4	7	3	<i>\</i>	9	F†
Wick-Stage Mode 2 2 3 2 3 1 3 1 Expendable Payload 1 1 1 1 1 1 1 3 1 8 Single Payload 1 <td></td> <td>Multi3 Payloads</td> <td>Τ</td> <td>†</td> <td>1</td> <td></td> <td></td> <td>2</td> <td>2</td> <td>П</td> <td>3</td> <td></td> <td>1</td> <td>15</td>		Multi3 Payloads	Τ	†	1			2	2	П	3		1	15
Expendable		Kick-Stage Mode			2		2		ω.	ય				6
Retrieve Single Payload Single Pay	80	Expendabl.e					2		7	7		3	7	.8
Retrieve Single Payload Cond Trip Cond Trip </td <td>ight stribution</td> <td></td>	ight st ri bution													
Single Payload A	3	Retrieve												
Round Trip Round Trip <td></td> <td>Single Payload</td> <td></td>		Single Payload												
Round Trip Round Trip A cond Trip														
Deploy 1/Retrieve 1 Cortie		Round Trip												
Deploy Multi/Retrieve 1 A cortie				·			·							
Sortie Total 25 23 24 29 29 23 25 33 27 24 26 Retrieve 0		trieve		·			.,	,						
Total 25 23 24 29 29 23 25 33 27 24 26 Retrieve 0		Sortie								,				
Deploy 25 23 24 29 29 23 25 33 27 24 26 Retrieve 0 <td></td> <td>Total</td> <td></td>		Total												
Retrieve 0<		Deploy	25	23	54	29	29	23	25	33	27	77	56	288
	ssion Model	Retrieve	0	0	0	0	0	0	0	0	0	0	0	0

FLIGHT SUMMARY-WIR-OPTION 1

·						Calendar	:	Year					
	Flight Mode	80	81	82	83	18	85	98	87	88	89	96	Total
***************************************	Shuttle	0	0	0	7	2	5	3	7	2	7	2	32
Totals	Tug	0	0	0	7	2	5	ω	. 	2	7	2	32
	Deploy												
	Single Payload												
	Multi2 Payloads				3	7	2	2	2	2	n	7	16
	Multi3 Payloads				М	7	a	-	7		3	7	12
	Kick-Stage Mode							-					
Tug	Expendable								i.				
Flight Distribution													
; ; ; ; ; ; ; ; ;	Retrieve												
	Single Payload												
	Round Trip												
	Deploy 1/Retrieve 1												
	Deploy Multi/Retrieve 1				-								
	Sortie				7		н		н,		Н		†
	Total												
	Deploy	0	0	0	16	5	11	7	8	17	16	5	72
Mission Model	Retrieve	0	0	0	⊣	0	7	0	1	0	7	0	7

2.1.2 Missions Not Captured

The availability of the Shuttle in 1980 limits Tug flights to 3. With this constraint the payloads selected for these flights were based upon the following rationale:

- 1. The first flight would be a simple flight with a light payload (although large enough to warrant use of the STS). NASA Mission 4 was selected.
- 2. The second flight would be a simple flight with a heavy payload. NASA Mission 8 was selected.
- 3. The third flight would add the complexity of multi-payloads (note that for Option 1 no orbit maneuvering is required for the placement of multiple payloads). NASA Mission 3 and 2 payloads of Mission 1 were selected.

The following missions were not performed in 1980:

<u>N</u>	<u>asa</u>	DOD	
MISSION	NUMBER OF PAYLOADS	MISSION	NUMBER OF PAYLOADS
2	1	2	2
3	2	3ъ	1
6	1	15	1
7	1	3a	Σį
8	1	46	ı
9	1	8	2
11	1		
17	1		

All other missions both NASA and DOD were performed as required

2.2 Additional Payload Capture

The capability of the Option 1 Tug to capture missions beyond the Option 1 mission model is illustrated in Table 2-6 which indicates the mode in which the Option 1 Tug can capture various missions. The missions identified are those which are contained in the total mission model but are excluded in the Option 1 mission model.

NASA Missions 9, 17, and 18 can be flown in the normal Tug single payload deployment mode. NASA Missions 19, 23 and 24 can be flown by normal expendable Tug mode. NASA Mission 20 can be flown in the normal kick stage mode (with a Polaris kick stage).

NASA Mission 22 can be performed in a mode where both the kick stage (a Polaris) and the Tug are expended.

DOD Missions lla, llb, and llc are eliminated from normal mode operation since transfer orbit periods (about 40 hours) are beyond the Option 1 duration capability. The mission can be performed, however, by using an injection kick stage and flying the Tug on a flight path similar to interplanetary mission flights. After burn into the transfer orbit the Tug separates retro-burns and returns to the Shuttle. The kick stage and payload coast to 58,000 n.mi where the kick stage provides the velocity to correct the velocity vector for proper orbital conditions.

DOD Mission 12b cannot be performed by the Option 1 Tug due to payload roundtrip weight capability being less than 2400 pounds.

N = NASA D = DOD

TABLE 2-6
OPTION 1
ADDITIONAL PAYLOAD CAPTURE POTENTIAL

	T	í	1	<u> </u>	 I		Τ-	!	ī	- -					 _	·		-,-	٦		 -	
		SORTIE		E	•		•					•	•	•							•	
CANDIDATE CONFIGURATION 1	TUG MODE	RETRIEVE			•	ſ	•			1	ı		•							000	4	57
NDIDA			ω	m	a	8	7	7	2	4		6	.6	6			-		57	,	,	
CAI		DEPLOY	Normal	Normal	Normal	Expendable	Kick Stage	Expend/ Kick Stage	Expendable	Expendable		Kick Stage	Kick Stage	Kick Stage								
)n mode	SORTIE		,	•		•	1	ı	1	1	5	•	1	1						1	5	
OPTION MISSION MODE	RETRIEVE		ı	ı	8	ı	1	1	8	ı	ı	1	8	1						ı		29
1	DEPLOY		8	က	2	3	77	4	2	η	1	6	6	6					57	ā		
MISSIONS EXCLUDED FROM	DESIGNATION	ΙM	1400	2000	3300	7900	1500	η000	0099	1400	5400	850	850	850					DEPLOY	RETRIEVE	SORTIE	TOTAL
MISSIO	DESI	I.D. #	6 N	N 17	N 18	N 19	N 20	N 22	N 23	и 24	D 12b	D.11a	D 11b	D 11c						TOTAL		

2.3 FLIGHT DATA

2.3.1 Flight-by-Flight Mission Assignments

The following table (Tables 2-6) present the flight by flight mission assignments for each of the Tug flights for each year of the program. ETR and WTR launches are shown on separate pages.

Each chart shows the following data:

- Flight Number numbering of flights which is arbitrary and has no relation flight sequence or schedule.
- Orbit Mission orbit defined by altitude and inclination. In the case of interplanetary missions the mission velocity is given.
- Flight Mode the flight mode the Tug will operate to perform the mission. Flight modes used by the Option 1 Tug are defined as follows:
 - A single payload deployment
 - A() multi-payload deployment
 - A-KL payload deployment using kick stage (planetary mission)
 - A-E payload deployment expending the Tug (planetary mission)

- UGHT		: ETR	PAYLUADS	T	PAYLOAD	· , 00
NO	OLBIT	í	UP	WEIGHT		WEIGH
- 		MODE	UF	ļ	DOWN	
4100	<u> </u>		 	<u> </u>	ļ	ļ
NATION	7 7-616	A A A(3)		 		
	SYNC . EQ	<u> </u>	4 8 3/,/	1500		
===	SYNC. EQ	A	8	3500		
	SYNC, EQ	A(3)	31,1	2100		
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7007		<i>-</i>			<u>`</u>	ļ
DOI	DNE	GHTS	ļ			
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FUGHT	\A00	FLIGHT	PAYLUADS	1.,,,	PAYLOND	
FUGHT NO.	OCBIT	MODE	UP	WEIGHT	DOWN	WEIGHT
		!		•		
NA	AFI	IGHTS				
/	SYNC, EQ		8	3500		
7	"	A	3			·
	 	 	1//	3000		
		A(3)	4,4,1	2500		
4	b1	A(3)	3, 3, 3	3300		-
5	,,	A(3)	3,3,3	3300	-	-
2 3 4 5 6 7 8	4.	A (3)	3,3,3 3,2,2	2700	-	_
7	6400 / 550	A	10	6000	_	_
8	30×16×/29	A	//	800	_	_
DOI	FLIC	HTS				
1		A	4a	3480	_	_
フ		<u> </u>	40	3480		
2 3 4 5	 	A A(2)	72	1335		
3	1		2,2	1380		
4	 	A	10	2745		ļ <u>-</u>
ح		A	8	2430		ļ <u>-</u>
6	ļ		B	2430		ļ
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LAUNCA	4 SITE	ETR		Υ.	EAR	1982
FUGHT	ORBIT	FLIGHT	PAYLUADS UP	WEIGHT	PAYLOAD	WEIGHT
		7-100E			DOWN	
NA	SAE	LIGHT	-<	 		
/	SYNC. EQ	A	8	3500		
2	"	A	7	3000	_	
3 4	,,	19(2)	7.1	3500	-	_
4_	"	A(2)	3,3,3	3100	_	
5 6 7	11	A(3)	3,3,3	3300		-
7	23000 fg 3	B	9	750		-
8	23000 875	A-KL	20 20	900		
		/		700		
Doi	D FL	14HTS				
		A	15	1970		-
3 4 5 4		A(2)	36	1570	tu-	-
4		A	46	1380 3480	-	
5		A	46	3480		
6		A	8	2430	-	-
7		_A	8	2430	-	-
8		A(2)	3a 3a	3140		-
J7		A (2)	3a,3a	3140	-	
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HUNCH	1 3/12	ETR	•	Y	EAR.	1983
FUGHT NO.		FLIGHT	PAYLOADS		PAYLOAD	
NO	OLBIT	MODE	UP	WEIGHT	NIMOCI	WEIGHT
		77002			3000	
NAS	A F4	IGHTS				
	SYNC. EQ	A	8	3500	_	_
2	,		8	3500	·	
	,,	A A(2)		3500		
3 4 5		4(2)	7, 1	3500		-
4	**	A A(2)	7	3000	-	-
5	••	A(2)	5, 2	2600	-	_
6	4.	A	5	1800		
7		A	5 5			
	11		<u> </u>	1800		
8_	"	A(2)	3,4 3,3 4	2600		-
9	- 11	A(2)	3,3	2200	-	-
10			4	1500	-	-
//	30Kx16K/29	A	11	800		
	761	<u> </u>	//	- 000		
		 				
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Do	DEI	GHTS				İ
	,		13	2220	 	
		A	17			
2		17	17	2220	<u>-</u>	ļ
3		A	15	1970	-	-
4		A	36	1570	-	-
5		A(2)	2, 2	/38v	_	_
				2745		
6	· · · · - · · · · · · · · · · · · · · · · · · ·	A	10	2/45		ļ — — —
		14	46	3480		
8		A	8	2430	_	
9		A	8	2430	-	
10		A(2)	34.34	3140	-	-
		A(2)		3140		
		77 (2)	3a,3a	3/70	ļ	
						
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FLIGHT PAYLOADS WEIGHT PAYLOAD WEIGHT LAUNCH SITE WTR FUGHT OLBIT WEIGHT NO. NASA - FLIGHTS

1 500/99 A(3) 16/6/5 6200

2 11 A(2) 16/6 5200

3 VARONZITS A(3) 12/13/14 2250 DOD FLIGHTS A(3) 555 2205 BA 12a 6000 124 A(2) 16,16 5220 4 16,16 5220 A(2)

-101461	7 3/1/2	ETR			EAR:	1484
FUGAT	OLBIT	i -	PAYLUADS	WEIGHT	PAYLOAD	
NO.	00517	MODE	UP	WEIGHT	NOWN	WEIGHT
NA		LIGHT	<u> </u>			
/	SYNCEQ	<i>A</i>	8	3500	_	-
2	41	A	8	3500	-	_
3	**	19	7	3000		-
3 4 5	"	A(2)	4,1	2000	_	_
5	,,	A (2)	3, 1	1600	-	_
6	1 AU.	A	9	250	-	-
7	6900 /55	A	10	6000	_	-
8	13000 SPS	A	18	2000		-
9	.,	A	18	2000		_
10	23000 995	A-KL	20	900		
11	*(A-KL	20	900		
12	22000 495	A-E	24	3300	_	-
13	41	A-E	24	3300		
				3300		<u> </u>
						
	 					
DOD	611	GHT S				
I	F C1			222/2		
2		A	17	2220 5750		-
			17			
3_	 	A		1970		
4 5			49	3480		<u>-</u>
		A	4a 3b	3480	<u> </u>	-
9		74	3 D	1570		
8		A(2)	2,2	1380		
9			8	2430	<u> </u>	
10	 	A	3a 3a	2430		
		A(2)		3140		
	 	A(2)	34,34	3146		-
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FLIGHT	OLSIT	FLIGHT	PAYLUADS		PAYLOAD	I
NO.	OLBIT	MODE	UP	WEIGHT	PAYLOAD DOWN	WEIGHT
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NA	SA F	LI GHT A(2)	3			
	LOW AUT	A(2)	14,15	1400		
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	<i></i>	1GHTS A(3)	555	2205		
						
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FUGHT NO.	APRIT	-	PAYLUADS	WEIGHT	PAYLOAD	WEIGHT
NO.	00377	MODE	UP		DOWN	VE.0131
		·				
NA	SA F	LIGHT	Ś			
/	SYNC. EQ	A	В	3500		
7	11	A		3500	-	
7	•,,	A	\$	3000		
4	••	A	7	3000	-	-
2 3 4 5	4	A	6	2600	-	_
. /-	,1	A(2)	33	2200	_	_
-67	••	A(3)	3,3 3,3,3 4,1,2	3300	_	
Ŕ	**	A(3) A(3)	4/2	2800	_	_
8	30 X 16 K/29	A	 	800		
	,61			- 222	 	
				<u> </u>		-
			†			
Do	D =	LIGHTS	<u> </u>	 		
	<i>V</i> – –	A	15	1970		
			6	3480	 	
		A	1	3480		
2 3 4 5		A $A(2)$	2,2	1380	-	-
		19(2)	46	3480		-
6		A	46	3480	<u> </u>	·
	ļ	7				
		A	8	2430		-
	<u> </u>	A	8	2430		
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FUGHT	OLBIT	FLIGHT	PAYLUADS	WEIGHT	PAYLOAD	}
<i>NO</i> .	02377	MODE	UP	WEIGHT	DOWN	WEIGHT
	ļ				<u> </u>	
NA	5A-F	LIGHTS	S			
	COW ALT	A(3)	12,13,14 16,16,15 16,16	2250		
<u> 2</u>	SOU /GE	A(3)	16,16,15	6200		
	500 /99	4(2)	16,16	5 200	-	
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D	D) F	LIGHT	S			-
		BA	12a	6000	12a	6000
<u> </u>		A(2)	16,16	5220		
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LIGHI		FLIGHT	PAYLUADS		PAYLOAD	
NO.	OLBIT	MODE	UP	MEIGHT	DOWN	WEIGHT
		·				
NI	SPA F	LIGHT	<u> </u>			
	SYNC, EQ		8	3500	_	
2	1.	A	8	3500		
3	••	A(3)	333	3300		
4	/.	A(3)	3,3,3	2700		-
4 5 6	I AU.	A(2)	99	1500		
6	16500 fgs		19	5500		_
7	18400 fes	AKL	23	5000	_	_
7 8	11	A-KL	23	5000	_	
9	24000 fgs	AE	22	2500	_	_
Do	D F	LIGHT:	5			
1		A	17	2220		_
2 3 4 5		4	36	1570	_	
3_		A(2)	2,2 45 8	1380	-	
		A	46	3480		
		9	8	2430		-
6		A	8	2430		
7		A(2)	3a,3a	3140	<u>-</u>	-
	 	A(2)	30,30	3140		-
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NO.	OLBIT		PAYLUADS UP	WEIGHT	PAYLOAD	WEIGHT
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NA	50 6	L16H	7			
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1	MARIOUS HEW ALT	A(2)	14.15	1400		
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Du	DF	UGNTS A(3) A(2)				
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2		A(2)	16,16	5220		
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FUGHT NO.	APRIT		PAYLUADS	WEIGHT	PAYLOND	
<i>₩</i> 0.	OCS //	MODE	UP	WEIGHT	DOWN	MEIGH
N	05A F	LIGHT	<		 	
/	SYNC. EQ	9	8	3500		
	1,	B		3500		
3	• •	A	R 7	3000	ļ ———	
	•1	A		3000		<u> </u>
	и	A(2)	61	3100		
6	L.	A(3)	7 (e, 1 3,3,3 4,3	3300		
	10	A(2)	4/2	2600		
8	1,	A(2)	4,2	2300		
9	11	A(2)	3,3	2200		
/0	6900/55	A		6000		
11	30 × 16 K/29	A	10	800	_	
	16500 fgs	A-KL	19	5500		
13		A.KL	19	5500		
	24000 fps	A-E				
	240.0 173	77-2	22	2500		-
·····						
	OD FL	IGHTS	·			· · · · - · · · · · · · · · · · · · · ·
—— <u>-</u>		<u>A</u>	15	1970		
<u>2</u> 3		$\frac{A}{a}$	6	3480	-	
<u></u>		A	44	3480	· · · - · ·	
4 5		A	4a	3480	<u> </u>	
		A	36 2,2	1570	-	
7		A(2)	2, 4	1380		
8		4	B B 3a,3a	2430		
9		A	_ 8	2430		
		A(2)	34,34	3140		
10		A(L)	34,34	3140		
		· · · · · · · · · · · · · · · · · · ·				
						
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HUNC F	1 3172			,Y	L'AK I	1981
FUGHT	OPRIT	FLIGHT	1	WEIGHT	PAYLOAD	WEIGHT
₩ 0.	000	MODE	1 07	W - 10 17 1	DOWN	VEIGITI
		LIGHT A(2) A(2)				
NA	95A - F	LIGHT	5			
/	LOW PLT.	A(2)	1415	1400	-	-
2	//	A(2)	12 13	1850	-	_
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7	D F	1GHTS A(3) BB		<u> </u>		
		A(3)	<<<	2205		†
_ / 		Ba	13,	6000	12a	6000
		3.5	124	0000	152	1000
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FUGHT	_	FLIGHT	PAYLOADS		POVIDOR	
FUGHT NO.	OLBIT	MODE	UP	WEIGHT	DOWN	WEIGHT
		-				
1/4	AFL	16HTS	· · · · · · · · · · · · · · · · · · ·			
			0	3500		
	SYNC. EQ	1	8			
	<u> </u>	A	8	3500		-
3 4 5 6	l (A	7	3000		_
4	n	A	4	1500	_	-
5	H	A(3)	3,3,3 3,3,3 3,1,1	3300	_	
10	1,	A (3)	3 3 3	3300		
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3 4		A	36	1570	_	
4		19(2)		1380	_	-
5		A	2,2	3480		_
6	1	A	41	3480	_	
		A	4 b B	2430	 	
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		ETR		Υ.	EAR	1987
FUGHT	OLSIT		PAYLUADS		PAYLOAD	
NO.	02377	MODE	UP	MEIGHT	DOWN	WEIGHT
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3	11	A	7	3000		-
4 5	4	A(2)	5, 1 5, 2 5 3,3	2300		-
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<u> </u>	<i>h</i>	A A(2)	3	1800		-
3	30 KILK 24		2,3	2200		-
9	13000 fps	A	11	800	<u>_</u>	
10	11	A	17	1000		
11	24000 195	A-E	22	1000		-
12	22000 fps	A.E	24	3300		
/3		A-E	24	3300		
				7500		
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D_0	DEL	IGHTS				
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2		A	17	1970	<u></u>	
3		A	6	3480	-	
		A A(2)	2, 2	1380	·	
<u>5</u>		A		2745	***	-
		A	10 B	2430	_	
7		A	8	2430	_	4
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/	VARIOUS 500 / 99	A(3)	16,16,15	6200		
_ 	300 / 99	A(2)	16,16	5200		
3	140040134	A(2)	16,16	5200		-
4	VARIOUS	A (3)	16,16	2250		
						
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Do	~ =	LIGHT	<u> </u>			
1	· · · · · · · · · · · · · · · · · · ·	A(3)	555	2205		
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FUGAT OCS.T FLIGHT TANLOADS WEIGHT PAYLOAD NO. OCS.T FLIGHTS 1 SMIC.EQ A B 3500	LANING	1 311E	ETR		Υ.	EAR.	1990
NASA FLIGHTS 1 SYNC.EQ A 8 3500	FUGAT	A80.T		PAYLUADS		PAYLOAD	
NASA FLIGHTS 1 SYNC.EQ A B 3500	NO.	02377	MODE	UP	WEIGHT	DOWN	WEIGHT
7 SYNC.EQ A B 3500							
7 SYNC.EQ A B 3500	4/4	050	-, 10-41-	~	 		
2 " A B 3500 3 " A(2) & 1 3100 4 " A(2) & 1 3100 5 " A(3) 3,3,3 3300 6 1AU A(2) 5,9 1500 7 4900 /55 A /0 6000 8 24000 ffs A-E 22 2500 2 A 15 1970 3 A 44 3480 4 A 3480 4 A 362 2430 8 A 8 2430 9 A(2) 3a,3a 3140	107	() / (C)		2			
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6 1 Av. A(2) 9,9 1500			A				
6 1 Av. A(2) 9,9 1500	3	11		6,1	3100		_
6 1 Av. A(2) 9,9 1500	4	*1	A(2)	6,1	3100	_	-
DOD FLIGHTS A 17 2220		11	A(3)	3.3.3		_	-
7 6900 /55 A /O 6000		I AU.		99		_	_
8 24000 fys A-E 22 2500 DOD FLIGHTS 1 A 17 2220 2 A 15 1970 3 A 4a 3480 4 A 3b 1570 6 A(2) 2,2 1380 7 A 8 2430 9 A(2) 3a,3a 3140		6900 /55				_	
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7 A '8 2430			A	36	1570	-	
7 A '8 2430	6		A(2)			-	-
3 A B 2430 9 A(2) 3a,3a 3140	7		A	8		-	-
9 A(2) 3a,3a 3140	2		A				
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NO.	OLBIT	FLIGHT	PAYLUADS UP	WEIGHT	PAYLOAD	WEIGHT
		7700E			30WA	
<u> </u>	054	11/47	<u> </u>	 		
	VARIOUS _	LIGHT: A(2)	1415	1400	 	·
	LOW AUT.	7(2)	17,73	1700		ļ
				 		
					 	
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2.3.2 Mission Model

The mission model for Option 1 is provided in the following table (Table 2-7). This is the mission model provided by the Government and is repeated here for completeness. The data shown on the table includes:

- 1. Mission Number (and DOD identification number for DOD missions)
- 2. Payload Weight (in pounds)
- 3. Payload Length and Diameter (in feet)
- 4. Number of mission per year (1980 through 1990) for both up payload and down payload traffic.
- 5. Total traffic for each payload
- 6. Subtotal yearly traffic for NASA and DOD
- 7. Total yearly traffic

TABLE 2-7

MISSION MODEL OPTION 1



	90	TOTALS
65	2/	
	/	17
2 800 1/2//////////////////////////////////	17	7
3 1100 3 7 3 3 1 5 5 6 7 2	3/	45
4 1500 1 1 2 1 1 2 1	1	9
5 1800 3 3		6
6 2600 1 1 1 1	2/	6
7 3000 1 1 2 2 1 2 2 1 1	1	/3
8 3500 2 1 1 2 2 2 2 2 2 2	2/	20
9 750 1 1 2 1	2/	8
10 6000	17	4
" Boo 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1	6
12 1200 1 1 1 1	1/	4
13 650 1 1 1 1	1	4
14 400 11 11 11 11	1	8
15 1000 1 1 1 1 1 1	17	8
16 2600 4 4 6	1	14
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MISSION MODEL OPTION 1 (CONT.)

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23 5000 77 72	4
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1741 [2] / / / / / / / / /	4
27 17 12	'
SUB- TOTAL NASA 14 16 12 23 17 22 16 24 16 26 15	201/0

MISSION MODEL OPTION I (CONT.)

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	DOD	NEIGHT	80	81	82	93	0.1							
	1. D.	LD	1		<u> </u>	83	84	85	86	87	88	89	90	TOTALS
25	2	12 5	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	22
26	36	1570	1/		1	1/	1		1/	1/	1/		1/	8
27	15	16 10	1/		1	1/	1/	1/		1/	1/	1/	1/	9
28	17	12 10				2/	2/		1/		1/	1/	1/	8
29	126	2400		/			/							0
30	6	3480						2/		1/		1/		4
31	4a	3480 25 15		2/			2			2			Z	В
32	3a	1570	4/		4/	4	4/		4/	4/	4/		4/	32
33	46	3480 25 15	1/		2/	1/		2/	1/		2/	1/		10
34	10	2745		1/		1/								2.
35	8	2430 25 /2.7	2/	2	2/	2/	2/	2/	2	2	2/	2	2	22
36	1/4	96												O
37	116	850 9 6												0
38	1/ c	850 9 6												0
39	5	7 35 3 5				3/	3/		3/	3/		3/	3/	18
40	16	2610				4/		2/	2/		2/	2/		12
41	/2a	2010				1/		1/-		1/1		1/		4 4
SUB- TOTAL	DOD		11/0	7/0	12/0	22/	17/0	13/1	16/0	17/	15/0	14/	16/0	159/4
TOTAL			25/0	23/0	24/	45/	34/0	34/	32/0	41/1	31/0	40/	31/0	360/4

2.4 PROGRAMMATICS INPUT DATA

The following data was provided as a basic input to the programmatics studies. The first chart summarizes the total flights and hardware requirements. The second group of tables show the flight schedules and hardware requirements as a function of year. There are five tables in the group, an overall summary, NASA ETR, NASA WTR, DOD ETR and DOD WTR. These charts represent the data requested in NASA letter PD-TUG-P(028-74). The next chart shows the same flight requirements data in the format used by MDAC in the study. The final chart shows the usage of indivisual Tugs to accomplish the mission model.

At the top of the chart, the number of flights per year is shown and the number of Tug expendable flights. The number of Tugs required were established by first determining the number of Tugs necessary to accomplish the 1990 requirements and working backward from that point. The maximum number of flights any Tug can perform in a year is established first by summing the Tug ground turn-around time and the mission time which results in the minimum mission turn-around time. In option 1 the ground turn-around time is 26.7 days and the average mission time is 1.7 days. The mission turn-around time is thus 28.4. The maximum number of cycles (flights) in a year is then 12.

Using this number and assuming that the maximum number of flights that an expended Tug can make in the year that it is expended is 6 (one-half the maximum turn-around in a year), the fleet of 3 for 1990 is established. Working backward from there it can be seen that in 1989 the three expendable requirements and the necessary in 1990 make up the inventory requirement. The resulting data show that to carry-out the operations a total of 10 Tugs are required during the program.

The major influence on fleet sizing is the number of expendable Tug missions required. If, for example, no expendable missions were required the required fleet size could be reduced to three vehicles.

CONFIGURATION OPTION I

	REQUIRED	ACCOMPLISHED
DEPLOYMENTS RETRIEVALS	<u>360</u> 4	<u>341</u> <u>4</u>
FLIGHT REQUIREMENTS (NASA/DOD)		
# ETR LAUNCHES # WTR LAUNCH # REFLIGHTS DUE TO LOSSES		104/89 16/16 3
FLIGHT COMPOSITION		
EXPENDABLES (E) TUG WITH BURNER II (KS ₁) TUG WITH POLARIS (KS ₂) TUG (BASIC) VEHICLE LOSSES/REFLIGHTS		8 - 9 208 3 (228)
FLEET SIZE REQUIREMENTS		
FOR OPERATIONS FOR RELIABILITY		<u>10</u> 3
TOTAL		/3
REQUIREMENT AT IOC (MIN) FLIGHTS PER ARTICLE	·	722.5
- TANTO I DI WITTONE		~ C . 3

TURNAROUND CYCLE 28.4 DAYS LAUNCH TO LAUNCH (CALENDAR DAYS)

FLIGHT SCHEDULE

TUG CONCEPT OPTION 1

LAUNCH SITE ETR/WTR AGENCY NASA/DOD

COMPANY MDAC

	79	80	81	82	83	48	85	98	87	88	89	96	TOTAL
TUG (BASIC)**		3	ħΓ	16	30	(2) 26	22	(1) 21	(1) 28	20	(3)	(1) 20	(8) 228
AUXILIARY STAGE			ı	(2)		(2)		(3) (5)	(2)				(6)
DROP TANKS													0
(OTHER)	1*								_				1
SHUTTLE **	1*	3	14	16	30	56	22	21	28	20	28	20	529

() DENOTES NUMBER EXPENDED.

REMARKS: 20 payloads not accommodated due to Shuttle limit of 3 Tug flights in 1980

^{*} IVU Test Flight

^{**} Includes reflights due to Tug reliability losses

FLIGHT SCHEDULE

TUG CONCEPT OPTION 1

LAUNCH SITE ETR AGENCY NASA

COMPANY MDAC

	62	80	81	82	83	48	85	86	87	88	89	90	TOTAL
TUG (BASIC)		3	8	8	11	(2) 13	6	(1) 9	ήτ 1 ⁴ τ	8	(3) 13	(1) 8	(8) 104
AUXILIARY STAGE				(2)		(2)		(3) (2)	(2)				(6)
DROP TANKS													0
(отнев)	1*			·									н
SHUTTLE	1*	3	8	80	11	13	6	6	14	ω	13	æ	105

() DENOTES NUMBER EXPENDED.

9 NASA payloads not accommodated due to Shuttle limit of 3 Tug flights in 1980 * IVU Test Flight REMARKS:

FLIGHT SCHEDULE

TUG CONCEPT OPTION 1

LAUNCH SITE ETR AGENCY DOD

COMPANY MDAC

	79	80	81	82	83	†8	85	98	87	88	89	8	TOTAL
TUG (BASIC)			9	ω	11	77	ω	8	10	10	7	10	89
AUXILIARY STAGE													0
DROP TANKS										,			0
(отнек)													0
SHUTTLE			9	8	11	11	8	8	10	10	7	10	89

() DENOTES NUMBER EXPENDED.

11 DOD payloads not accommodated due to Shuttle limit of 3 Tug flights in 1980 REMARKS:

FLIGHT SCHEDULE

TUG CONCEPT OPTION 1

LAUNCH SITE WTR AGENCY NASA

COMPANY MDAC

	79	80	81	82	83.	ή8	85	98	87	88	89	90	TOTAL
TUG (BASIC)					m	1	3	п	2	1	4	٦	16
AUXILIARY STAGE													
DROP TANKS							·						
(OTHER)													
SHUTTLE				:	က	1	m	н	2	1	.a.	ч	16

() DENOTES NUMBER EXPENDED.

REMARKS:

FLIGHT SCHEDULE

TUG CONCEPT OPTION 1

LAUNCH SITE WTR AGENCY DOD

COMPANY MDAC

	79	80	81	82	83	†8	85	98	18	88	89	8	TOTAL
TUG (BASIC)					4	7	2	ય	2	Н	m	٦	16
AUXILIARY STAGE													
DROP TANKS													
(other)													
SHUTTLE					#	Н	2	8	2	7	м	н	16

() DENOTES NUMBER EXPENDED.

REMARKS:

FLIGHT REQUIREMENTS

OPTION 1

	T		T			·		 						
TOTAL.		87	. G	6	6		193		16	16	32			3
06			ç	2	1		18		-	7	2			
89		10	7			ı	20		7	8	2			1
88		8	10	•	1	,	18		п	п	8			
87		п	10	1	2		7₹		2	2	7			
98		5	8	1	3	'	17		٦	2	3			٦
85		6	æ	•		1	17		3	5	5			
78		6	ជ	2	2	ı	ħट		٦.	ri	2			
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82		9	80	ı	2		16		ŧ	ı	0			
81		8	9	ı	ı	ı	14		1	1	0			
80		3	1		1	ı	3		ı	ı	0			
	ETR	NASA	DOD	NASA EXPENDABLE	NASA KICK STAGE	DOD KICK STAGE	TOTAL	WIR	NASA	ООО	TOTAL			EFLIGHTS / LOSSES

EQUAL USAGE SCHEDULE

OPTION 1

TOTAL	225	8	14	21	† 7	23	5ħ	5ħ	ħ2	77	24	23		3
96	20	7								N	9	12		
89	27	3					2	2	0	5	8	11		7
88	20						2	8	3	10	3			
18	28	τ				3	2	2	4	10	7			
98	20	1			2	3	ή	ቱ	7					Н
85	22				3	3	4	ħ	8					
48	56	2	3	9	5	η	η	4						
83	29		3	9	9	9	4	ф						٦
82	16		2	2	ħ	7	S	2						
81	14		4	9	η									
80	3		2	1										
	NUMBER OF FLIGHTS	NUMBER OF EXPENDED TUGS	TUG ID 1	2	3	7	5	9	7	80	6	10		REFLIGHTS / LOSSES

2.5 SENSITIVITY STUDY DATA

2.5.1 Two Year IOC Delay

A two year IOC delay in the Option 1 program results in the loss of all missions in 1980 and 1981. In 1982 normal program results build up will allow the availability of three vehicles in 1982 thus allowing all 1982 missions to be accommodated.

The total number of flights necessary to accommodate the 9 year mission model (Option 1 mission model less the first two years) is 208. A total of 48 payloads in 1980 and 1981 are not accommodated due to the delay in IOC.

2.5.2 >36 Hour Duration

Impact of increasing the duration capability of the Option 1 Tug on the program is disguised by the capture analysis ground rules which allow multi-payload deployment with no longitudinal positioning between payloads. If the Option 3 ground rules were used, the 36 hour capability would limit synchronous operations to single deployment. If this were true the extension of duration capability to 3 days would allow multi-payload capability with longitudinal positioning and would save about 58 flights. Extension to 6 days would have only a small impact upon the mission capture (about one flight per year). These savings are due to the increased time available to walk the longitudinal position between the payloads.



SPACE TUG SYSTEMS STUDY (CRYOGENIC) SEPTEMBER DATA DUMP

VOLUME 4 Mission Accomplishment Book 2 Option 2

SEPTEMBER 1973

PREPARED BY: SPACE TUG STUDY TEAM

L. Q. WESTMORELAND

STUDY MANAGER

PREPARED FOR NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
UNDER CONTRACT NO. NAS8-29677

PREFACE

This study report for the Tug Program is submitted by the McDonnell Louglas Astronautics Company (MDAC) to the Government in partial response to Contract Number MASS-29677.

The current results of this study contract are reported in eight volumes:

Volume 1 - Summary, Program Option 1

Volume 2 - Summary, Program Option 2

Volume 3 - Summary, Program Option 3

These three summary volumes present the highlights of the comprehensive data base generated by MDAC for evaluating each of the three program options. Each volume summarizes the applicable option configuration definition, Tug performance and capabilities, orbital and ground operations, programmatic and cost considerations, and sensitivity studies. The material contained in these three volumes is further summarized in the Data Dump Overview Briefing Manual.

This volume contains mission accomplishment analysis for each of the three program options and includes the tug system performance, mission capture, and fleet size analysis.

Volume 5 - Systems (3 Books)

This volume presents the indepth design, analysis, trade study, and sensitivity technical data for each of the configuration options and each of the Tug systems i.e., structures, thermal, avionics, and propulsion. Interface with the Shuttle and Tug payloads for each of the three options is defined.

Volume 6 — Operations (3 Books)

This volume presents the results of orbital and ground operations trades and optimization studies for each option in the form of operations descriptions, time lines, support requirements (GSE, manpower, networks, etc.), and resultant costs.

Volume 7 — Safety (3 Books)
This volume contains safety information and data for the Tug Program. Specific safety design criteria applicable to each option are determined and potential safety hazards common to all options are identified.

Volume 8 — Programmatics and Cost (3 Books)
This volume contains summary material on Tug Program manufacture, facilities,
vehicle test, schedules, cost, project management SR&T, and risk assessment for
each option studied.

These volumes contain the data required for the three options which were selected by the Government for this part of the study and are defined as:

- A. Option 1 is a direct development program (I.O.C.: Dec 1979). It emphasizes low DDT&E cost; the deployment requirement is 3500 pounds into geosynchronous orbit, it does not have retrieval capability, and it is designed for a 36-hour mission. MDAC has also prepared data for an alternative to Option 1 which deviates from certain requirements to achieve the lowest practicable DDT&E cost.
- B. Option 2 is also a direct development program (I.O.C.: 1983). It emphasizes total program cost effectiveness in addition to low DDT&E cost. The deployment requirement is 3500 pounds minimum into geosynchronous orbit and 3500 pounds minimum retrieval from geosynchronous orbit.
- C. Option 3 is a phased development program (I.O.C.: 1979 phased to I.O.C. 1983). It emphasizes minimum initial DDT&E cost and low total program cost. The initial Tug capability will deploy a minimum of

3500 pounds into geosynchronous orbit without retrieval capability, however, through phased development, it will acquire the added capability to retrieve 2200 pounds from geosynchronous orbit. The impact of increasing the retrieval capability to 3500 pounds is also provided.

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Section 1 PERFORMANCE

1.1 PERFORMANCE GROUND RULES

The payload performance was determined using the classical impulsive velocity equation. The velocities employed were based on the three dimensional finite burning trajectory analyses performed during Task 1. Since most of the missions in the mission model did not exceed three days duration, this figure was used for establishing performance capability even though subsystems are sized for six days. A detailed simulation of the basic geosynchronous deployment mission taking into account the actual losses associated with each engine start and the velocity contributed by propellant settling forces was used to determine an equivalent specific impulse penalty of four seconds which was then used for all missions.

For the geosynchronous transfer, a velocity of 13,972 fps was used which represents the most unfavorable situation (from a performance point of view) of no low orbit phasing being required and the resulting injection to the transfer orbit being performed with only one burn instead of two. This velocity is approximately 80 fps greater than the most favorable two burn transfer injection. For the return, a velocity of 13,920 fps was used.

The following weights and engine data were also employed in the performance computations:

Shuttle Capability	65,000
Ancillary equipment (to install Tug in the Orbiter bay)	2,066
Vented during ascent	269
Tug gross weight at deployment from Orbiter bay	62,665
Tug burnout weight (includes FPR)	6,430
Propellant capacity (@5.5 EMR)	55 ,50 0
Engine chilldown and propellant settling (each start)	20
Vented in flight	78
Attitude control propellant Fuel Cell Reactants Engine Ca	o5 83 stegory II RL10
Thrust	15,000
I _{sp} (@6.0:1 EMR)	kso o
sp (60.0:1 EMR)	459.2

1.2 GEOSYNCHRONOUS PERFORMANCE

Based on the foregoing ground rules and data, the following geosynchronous orbit performance capabilities were determined at the nominal 6.0:1 EMR:

Deployment 7,640 (7,892)

Retrieval 4,814

Round Trip 2,953 (3,067)

By off-loading lox only on the round trip and deployment missions, an EMR of 5.5 could be used yielding a three second increase in ISP and the pyaloads shown in parentheses. For mission of greater (or less) than three days, the increase (or decrease) in on-orbit consumables must be corrected for using the factors given in Section 1.4.2. Figure 1.2-1 shows how the payload delivery capability decreases as payload is returned.

1.3 PERFORMANCE ENVELOPE

Figures 1.3-1, -2, and -3 present the payload-velocity envelope for the Option 2 Tug starting from 28.5 deg, 55 deg, and 90 deg inclinations, respectively. The significant variation with inclination reflects the Shuttle performance with launch azimuth. For missions below geosynchronous, specific impulse could be increased by off loading LOX only initially to reduce the EMR to 5.5 and gain up to three seconds.

1.4 PERFORMANCE SENSITIVITIES

1.4.1 General Mission Trade Factors

The sensitivity of payload to the two principal performance factors,—Tug inert weight and I_{sp}— are presented as a function of mission velocity in Figure 1.4-1.

1.4.2 Geosynchronous Trade Factors

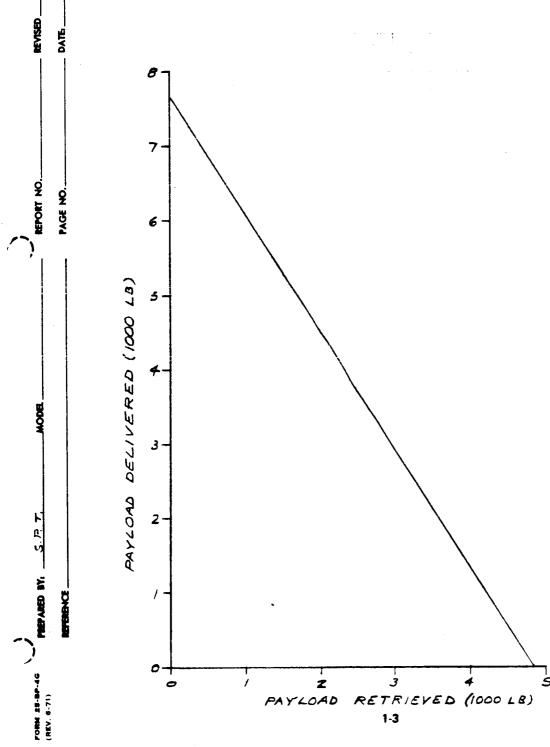
Specific trade factors for the geosynchronous missions are given in Table 1.4-1. The inert weight factor is applicable to any weight carried throughout the mission, such as structure and residual propellants. The gross weight factor can correct for variations in the Tug gross weight at first ignition such as Shuttle capability, ancillary equipment or propellants vented during ascent.

1.5 MISSION PERFORMANCE

The performance capability for each mission in the mission model was computed for each basic mission mode. The missions are defined in Table 1.5-1. Table 1.5-2 is a computer printout of the results and includes the velocities



GEOSYNCHRONOUS PERFORMANCE



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PERFORMANCE CAPABILITY

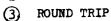
CONFIGURATION OPT 2

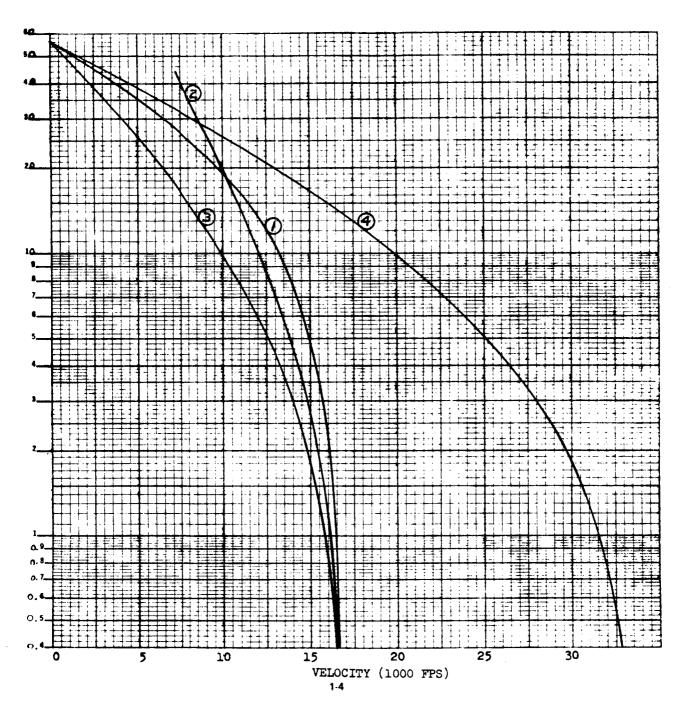
(4) EXPENDABLE

W_{BO} 6430

I_{SP} 459.2 INCL 28.5°

- 1) DEPLOY 2 RETRIEVE





PERFORMANCE CAPABILITY

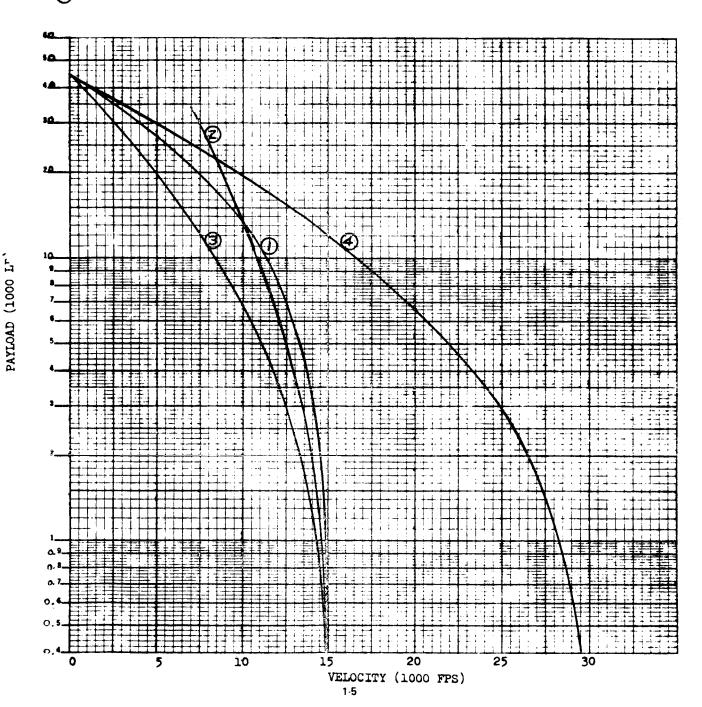
CONFIGURATION OPT 2

(4) EXPENDABLE

WBO _6430

I_{SP} 459.2 INCL 55°

- 1 DEPLOY
- 2 RETRIEVE
- (3) ROUND TRIP



PERFORMANCE CAPABILITY

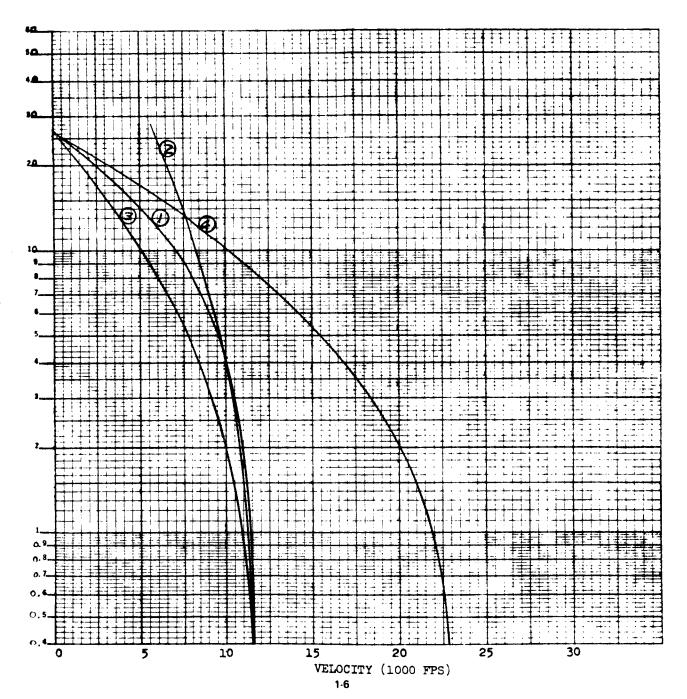
CONFIGURATION OPT 2

W_{BO} 6430

I_{SP} 459.2 INCL 90

EXPENDABLE

- 1) DEPLOY
- (2) RETRIEVE
- ROUND TRIP





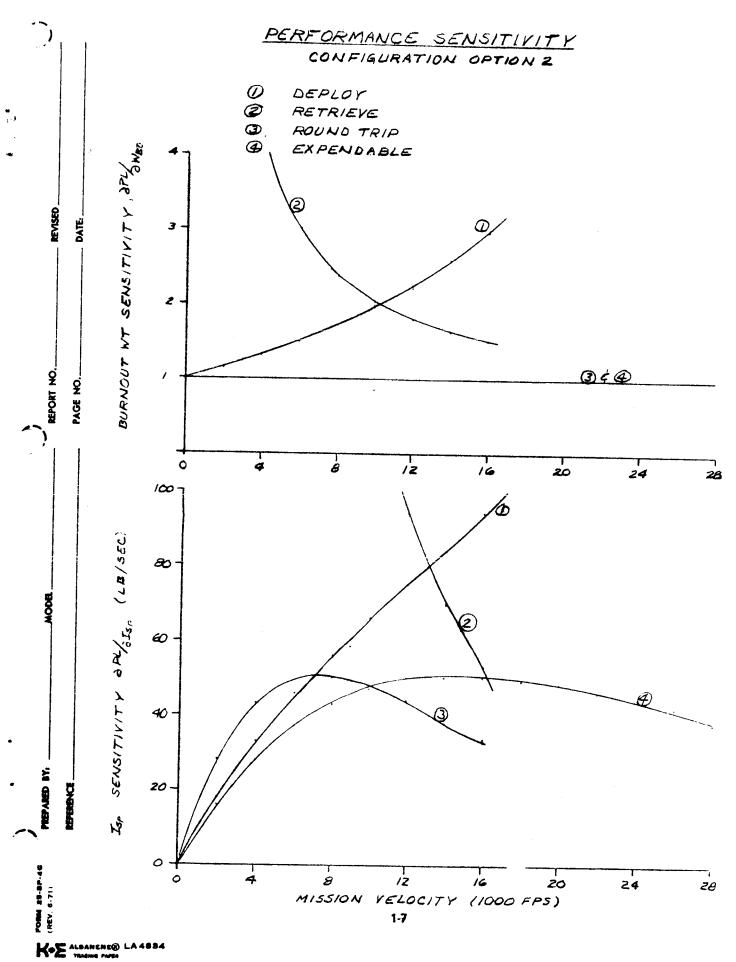


Table 1.4-1
GEOSYNCHRONOUS MISSION TRADE FACTORS

	DEPLOY	RETRIEVE	ROUND TRIP
Burnout Weight: SH JWEO	-2.57	-1.64	-1
Specific Impulse: OFL	84	70	38
Gross Weight:	•39	.25	.15
Orbit Losses: apl	-1	64	39

Table 1.5-1
MISSION DESCRIPTIONS

Mission No.	H _a x H _p (nmi)	Incl.	Remarks
1-8	19323	0	Synchronous orbit - single burn transfer orbit injection
1-8A	19323	0	Synchronous orbit - two burn transfer injection
1-8B	19323	0	Synchronous orbit - two burn transfer injection with 600 fps for multiple payload deployments
9	lau	Eclip.	
10	6900	55°	
10A	6900	55 °	Alternate - Shuttle launched into 28.5°
11	16Kx30K	20°	
12	180x1800	90°	•
13	1Kx20K	90°	
13A	1Kx20K	90 °	ETR Alternate - Shuttle launched into 28.5°
13B	1Kx20K	90°	ETR Alternate - Shuttle launched into 55°
14	300 x 3000	90°	
15	700	100°	
16	500	99.2°	
17-8	Interplane	etary	ΔV - 13000
19			16500
20			23000
21-2			24000
23			18400
24			22000
D11	58K	0,30,60	
D10	860x21K	63.4	Shuttle launch into 63.4° WTR
DloA	860x21K	63.4	ETR Alternate - Shuttle launched into 55°
D5	750	99°	·
D3	13.6Kx25K	60°	Shuttle launched into 60° WTR
D3A	13.6x25K	60°	ETR Alternate - Shuttle launched into 55°
D12	300	104°	
D16	400	98.3°	

CØNFIGUR	ATIØN ØPT 2	STAGE WT	=6430.00 I	SP=459.20 Di	ELISP=4.00
MISSIØN	GRØSS-WT V-ØUT	PL-RØUND V-BACK	PL-DEPLØY	PL-RETRI E	JE PL-EXPEND
1-8	62665.00 13972.00	2900•97 13920•00	7504.50	4729.05	17708 • 20
1-8A	62665.00 13890.00	2953•36 13920•00	7640.02	4814.46	17843.73
1-8B	62665•00 14190•00	2576•71 14220•00	6803.62	4147.47	17351 • 56
9	62665.00 14160.00	2515•42 14350•00	6701 • 01	4027.12	17400-33
10	50665.00 9700.00	7041.89 9700.00	13656-17	14539 • 03	19695.72
10A	62665.00 12760.00	4541.49 12760.00	10853.71	7808.99	19790.77
11	62665.00 12450.00	5015.93 12450.00	11736-50	8759•61	20351.70
12	32665.00 2285.00	17479 • 28 228 5 • 00	20430.62	121000.06	21516.32
13	32665.00 8 400.00	3942.95 8400.00	6996•99	9033•53	11977•40
13A	62665.00 13460.00	3541.27 13460.00	8877.61	5891.30	18 566 • 99
13B	50665.00 11200.00	4546.61 11200.00	9768.05	8505•62	17152.41
14	32665.00 3600.00	13549 • 12 3600 • 00	17324-65	62172.59	19116.39
15	26665.00 1700.00	14710.73 1700.00	16521•33	134232-19	17312.73
16	26665.00 1120.00	16453.28 1120.00	17760-87	223484•31	18271.88
17-8	62665.00 13140.00	3908 • 72 13250 • 00	9659•28	6565•52	19119-18
19	62665.00 16740.00	•00 17210•00	•00	•00	13551•32

20	62665.00	•00	•00	•00	6121.14
	23550.00	24500.00			
21-2	62665.00	•00	•00	•00	5252.79
	24600.00	25500.00		•00	3232.19
23	62665.00	•00	•00	00	
	18720.00	19550.00	•00	•00	11024-61
24	62665.00	•00	•00	•00	7054.02
	22500.00	23500.00		100	7034.02
D11	62665.00	2921.38	7562.46	4760.28	17777.53
	13930.00	13930.00			17777030
D10	48 665 • 00	8814.24	15515		
	8500.00	8500.00	15748.55	20018.09	20807.13
DIOA	50665.00	68 59 • 1 6	13392.96	14059.91	19517.94
	9800. 00	9800.00		14037171	1951/•94
D5	26665.00	14509 • 61	16373.53	127459.19	17199.53
	1770.00	1770.00			
D3	48 665 • 00	3217.77	7226.88	5800.43	15238 • 16
	11850.00	11850.00			
D3A	50665.00	3518-71	7940•63	6318.73	16021-10
	11920.00	11920-00			
D12	26665.00	18475.09	19116.72	550454.06	19340.03
	500.00	500.00			
D16	26665.00	17312.75	18347.27	307044.75	18731.49
	850.00	850.00			

derived from Task I. The gross weight reflects the Shuttle delivery capability to the appropriate parking orbit inclinations. In several cases, alternate mission profiles are shown starting from different inclinations. The capabilities with a kick stage were also determined for use in the mission capture analysis but are not shown simply to avoid classifying any data.

Section 2 CAPTURE ANALYSIS - OPTION 2

2.1 FLIGHT SUMMARY

The data provided in Section 2.1.1 represents a summary of the mission captured by the Option 2 program based upon all constraints of the system potential (Tug capability) and the program schedule (Tug and related support systems availability). Section 2.1.2 identified the missions, from the Option Mission Model, which are not captured by the program and also includes the rationale for their exclusion.

2.1.1 Flight Summary Data

Tables 2-1 through 2-5 present the number of flights per year for each of the flight modes used in Option 2. Also shown are the total Shuttle and Tug flights and the number of missions identified as requirements in the Option Mission Model. On Table 2-1 the number of missions accomplished is identified.

The mission modes used in this option are defined as follows:

Deploy

- Single Payload The deployment of one payload to one location and velocity vector and return of the Tug to the Shuttle.
- Multi 2 Payload The deployment of two payloads to one location and velocity vector and return of the Tug to the Shuttle.
- Multi 3 Payloads The deployment of three payloads to one location and velocity vector and return to the Shuttle.
- Kick Stage Large The deployment of one or more payloads to one location and velocity vector using a Polaris kick stage as a second stage to the Tug. The kick stage is expended and the Tug returns to the Shuttle.
- Expendable The deployment of one payload to one location and velocity vector. The Tug is expended.

Retrieval

Single Payload - The retrieval of one payload from one location and return to the Shuttle.

Round Trip

- Deploy 1/Retrieve 1 Deploy one payload at one location and velocity vector (maneuver 60° phase angle position for synchronous equatorial mission between deployment and retrieval), retrieve one payload and return to the Shuttle.
- Deploy Multi/Retrieve 1 Deploy one payload at one location and velocity vector, maneuver to a second position and velocity vector and deploy second payload, if three satellites are to be deployed, maneuver to a third position and velocity vector and deploy third satellite and retrieve another satellite at that position (for synchronous equatorial mission each maneuver shall be 60° phase angle).
- Sortie Carry a payload to one orbital location, remain in that orbit for 130 hours and return the payload to the Shuttle.

MARY—OP	FLIGHT SUMMARY-OPTION TOTAL-OPTION 2					,	5						:
						Calendar	- 1	Year					
Ligh	Flight Mode	80	81	82	83	84	85	86	87	88	89	90	Total
Sh	Shuttle					20	32	35	37	30	33	35	222
T	Tug					20	32	35	37	30	33	35	222
Ă	Deploy												
S	Single Payload					9	2	7	5	2	7	3	23
Ā	Multi2 Payloads					7	1	1	-7		4	٦	12
MU	Multi3 Payloads					Т	1	1	2	8	2	2	12
Κî	Kick-Stage — Large						-	M	2				5
Ex	Expendable							п	٠,٦		٣	1	·
Re	Retrieve												
Si	Single Payload						Н	9	9	4	7	9	5¢
			•										
RC	Round Trip												
ă	Deploy 1/Retrieve 1					8	24	22	15	19	16	21	125
Ğ	Deploy Multi/Retrieve 1					77	2		1	2	2	1	12
So	Sortie						1		1		1		3
	Total												
Ă	Deploy					37	37	32	41	34	43	34	258
Re	Retrieve					27	28	28	23	25	20	28	179
To	Total					1 79	65	09	1 9	59	63	62	437
Ĭ	Total					39	65	09	779	59	63	62	412
1													

FLIGHT SUMMARY-NASA-OPTION 2

				-		Calendar	1	Year					
ĻĒ4	Flight Mode	80	81	82	83	84	85	98	87	88	89	90	Total
	Shuttle					10	20	18	17	13	19	17	114
Totals	Tug					10	20	18	17	13	19	17	114
	Deploy												
	Single Payload					77			3	1	3	1	12
	Multi2 Payloads							H			7	-	9
	Multi3 Payloads								М	2			3
	Kick-Stage Mode							w.					3
Tug	Expendable							ч	:		С	П	.5
Flight Distribution													
3	Retrieve												
	Single Payload						1	3	2	3		3	12
	Round Trip												
	Deploy 1/Retrieve 1					5	17	10	10	5	7	11	65
	Deploy Multi/Retrieve l					7	2		<u></u>	2	2		7
	Sortie								1				J
	Total												
	Deploy					17	22	16	17	16	56	15	129
Mission Model	Retrieve					17	50	13	13	10	6	14	93

FLIGHT SUMMARY—DOD—OPTION 2

						Calendar		Year					
ĬŦ.	Flight Mode	80	81	82	83	₹8	85	98	87	88	68	8	Total
	Shuttle					10	12	17	20	17	7,7	18	108
Totals	Tug					10	12	17	8	17	14	18	108
	Deploy												
	Single Payload					2	2	7	2	77	7	2	11
	Multi2 Payloads						п		7				9
	Multi3 Payloads			:		н	н	7	7	п	2	2	6
	Kick-Stage Mode							-	a				2
Tug	Expendable												∵ત
flight Distribution													
	Retrieve												
	Single Payload							m	#	7		m	12
	Round Trip												
	Deploy 1/Retrieve 1					M	2	12	5	17.	6	11	61
	Deploy Multi/Retrieve 1		:			m			7				7
	Sortie						7			.	-		2
	Total						-		1			-	ŀ
;	Deploy					20	15	16	77	18	17	19	129
Mission Model	Retrieve				-	13	8	15	10	15	11	7.7	86
							_	-					
										_			

FLIGHT SUMMARY—ETR-OPTION 2

						Calendar	1	Year					
<u> </u>	Flight Mode	80	81	82	83	814	85	98	87	88	89	90	Total
	Shuttle					20	54	26	29	24	24	30	177
Totals	Tug					20	ηг	26	29	24	24	30	177
	Deploy												
	Single Payload					9	2	1	5	2	7	3	23
	Multi2 Payloads					т		н	7		1	1	8
	Multi3 Payloads					н	1		П	3	1	٦	8
	Kick-Stage Mode							m	2				5
Tug	Expendable							1	. 1		3	1	9
Flight Distribution													
	Retrieve	-											
	Single Payload						1	2	2	2	1	4	12
	Round Trip												
	Deploy 1/Retrieve 1					8	19	18	14	15	13	20	107
	Deploy Multi/Retrieve 1		·.			†	1			2	7		8
	Sortie								,				
	Total												
	Deploy					32	56	25	33	30	27	29	202
Mission Model	Retrieve					23	21	20	16	19	15	5₫	138
								-		i			

Total 745 45 4 ⇉ 12 19 \sim α 99 4 8 5 5 Н N Q **_** Ś 86 9 9 α Н α Н 91 Н S 88 9 9 Ŋ **≠** _____ 9 87 ω 8 Н 4 _ ᡆ Н Н ω 86 9 9 Calendar Year 4 4 ω 85 ω ω Н Š Н Н \Box 87 S 4 83 82 81 8 Deploy Multi/Retrieve Deploy 1/Retrieve 1 Multi--2 Payloads Multi--3 Payloads Kick-Stage Mode Single Payload Single Payload Total Expendabl.e Round Trip Flight Mode Retrieve Retrieve Shuttle Deploy Sortie Deploy Tug Tug Flight Distribution Mission Model Totals

FLIGHT SUMMARY-WTR-OPTION 2

2.1.2 Missions Not Captured

A normal build-up of vehicles results in a limitation in the number of flights possible in the first year of operation. In the case of Option 2 a total of 20 are flown in the first year. The selection of payloads was based upon the following rationale.

- 1. WTR flights were not flown which would allow WTR start-up costs to fall later in the program.
- 2. All expendable missions would not be flown which would reduce initial fleet size.
- 3. Missions requiring kick stages would not be flown. This would allow Tug/kick stage integration and kick stage production to be delayed two years since no kick stages are required in 1985 either.
- 4. Retrieval missions are of lesser priority than deployment missions.

Using this rationale, 27 deployments out of 37 required and 12 retrievals out of 27 were accomplished. The missions not accomplished in 1984 are listed below.

NASA		DOD	
MISSION 1	NO. OF PAYLOADS	MISSION	NO. OF PAYLOADS
ETR DEPLOYMENT	rs	ETR DEPLOYMEN	TS
20	2	8	1
24	2	ETR RETRIEVAL	C.
ETR RETRIEVALS	3	2	_
]	2	٤	1
	_	4a	2
2	2	3a.	2
WTR DEPLOYMENT	rs .	Ja	۷
14	1	10	1
15	- 1	8	1
	-	WTR DEPLOYMEN	TS ·
WTR RETRIEVALS		5	3
12	1		•
13	1	WTR RETRIEVAL	5
14	1	NONE REQUI	RED
15	1		

All other mission requirements in other years are accomplished.

2.2 ADDITIONAL PAYLOAD CAPTURE

The capability of the Option 2 Tug to capture missions beyond the Option 2 mission model is illustrated in Table 2-6 which indicates the mode in which the Option 2 Tug can capture various missions. The missions identified are those which are contained in the total mission model but are excluded in the Option 2 mission model.

NASA Missions 8, 10, 17 and 18 can be flown in the normal Tug single payload deployment or retrieval mode. NASA Missions 23, 23 and 24 can be flown by normal expendable Tug mode. NASA Missions 19 and 20 can be flown in the normal kick stage mode (with a Polaris kick stage). NASA missions 6 and 7 can be retrieved in a normal retrieval mode after their orbital energy has been reduced. The reduction of the orbital energy is accomplished by using the excess capability in another mission to bring the payload part way back. The mode is called the "nudge" mode. The amount of energy applied to the payload to "nudge" it down detracts from the primary mission capability. In addition, the energy necessary to move to the proper longitudinal position and rendezvous with the satellite also detracts from the primary mission. There are other difficulties in performing the mission such as the cyclic wobble of synchronous satellites over a period of time which make rendezvous costly. These factors are infinite in their variation and can only be defined when investigating specific mission profiles. Due to these factors, a limitation of 1,500 fps was estimated as a maximum which could be applied in the "nudge" mode. Where additional velocity was necessary to bring the heavier satellites to a energy level from which they could be retrieved by the Tug, a separate Tug flight was specified (i.e., two Tug flights).

In comparing the cost of the two types of operation, it is obvious that utilizing the nudge mode saves about \$11.5 million for the one flight (Shuttle and Tug operations). The costs for performing the nudge operation should include about one third of the Shuttle/Tug operations cost of the flight in question, since on the average it would reduce Tug mission capability by about one third. Thus, the net savings would be about \$7 million over using the two Tug mode. However, in real operations surplus capability would probably be available on the two Tug flights that secondary mission could be performed. The conclusion appears to be that both operational modes should be available to the Tug operators.

DOD Mission 12b is performed by the Option 2 Tug in a normal round-trip mission mode as the round-trip weight capability of the Option 2 Tug is greater than 2400 pounds.

N = NASA D = DOD

TABLE 2-6
OPTION 2
ADDITIONAL PAYLOAD CAPTURE POTENTIAL

Marie DEPLOY RETRIENE SORTIE DEPLOY RETRIENE SORTIE	IS EXCL	MISSIONS EXCLUDED FROM OPTION MISSION MODE	TION MISSIO	N MODE	CANDID	CANDIDATE CONFIGURATION 2	5
1	TION	DEP	RETRIEVE	SORTIE		TUG MODE	
- 3 - Nudge 500tps 3 Nudge 600 fps 10 Nudge 600 fps 10 Normal 7 Normal 7 Normal 2 Normal Normal 2 Normal Normal 2 Normal Nor	M				DEPLOY	RETRIEVE	SORTIE
- 10 - 10	5000	•	3	ı		•	
- 7 - 1 Normal Normal 7 Normal 2 Normal 2 Normal 2 Normal 2 Normal 2 Normal 2 Normal 2 Normal 2 Normal 2 Normal 2 Normal 2 Normal 2 Normal Norma	5500	1	10	ı		1	
- 2 - Mormal 2 Morm	1,000	•	7	8			
2	9500	•	2	1			
2	2000	2	1	1			
3	3300	2	ı	•			
2	7900	3	1	ı	Stage		
μ - Expendable μ Normal μ - - Expendable μ Normal - - μ Normal Normal 19 - - - - VE - 22 - - VE - μ - - - ν - μ - - - - ν - <td>1500</td> <td>2</td> <td>ı</td> <td>ı</td> <td>Stage</td> <td></td> <td></td>	1500	2	ı	ı	Stage		
2 - Expendable 2 Carpendable 4 Normal - - - - - Normal - - 4 Normal Normal 19 - - - - VE - - 19 - - VE - - 19 - - - VE - - 19 - - - - VE - - 4 - <td< td=""><td>4000</td><td>†</td><td>ı</td><td>1</td><td></td><td></td><td></td></td<>	4000	†	ı	1			
h - Expendable h Normal - - h Normal - - h Normal 19 - - - 19 - - - VE - - 19 - - 45 - - - - -	0099	2	•	-			
- -	0044	4	1	ı		·	
VE - 22 - 19 - 22 14 - 145 - 145	2400	•	B	7			
VE - 22 22							
VE - 22 - 19 - 22 14 - 145 - 145							
19 - 19							
19 - - 19 - - VE - 22 - 22 - - - 14 - - - 145 145 145							
- 22 22	DEPLOY	19	•	ı	19	1	ı
- 1 - 1 - 1 ₁₅	RETRIE	VE -	22	ı	•	25	ı
45	SORTIE		ı	77	8		7
	TOTAT,		45			1,45	

2.3 FLIGHT DATA

2.3.1 Flight-by-Flight Mission Assignments

The following table (Tables 2-6) present the flight by flight mission assignments for each of the Tug flights for each year of the program. ETR and WTR launches are shown on separate pages.

Each chart shows the following data:

- Flight Number numbering of flights which is arbitrary and has no relation flight sequence or schedule.
- Orbit Mission orbit defined by altitude and inclination. In the case of interplanetary missions the mission velocity is given.
- Flight Mode the flight mode the Tug will operate to perform the mission. Flight modes used by the Option 1 Tug are defined as follows:
 - A single payload deployment
 - A() multi-payload deployment
 - A-KL payload deployment using kick stage (planetary mission)
 - A-E payload deployment expending the Tug (planetary mission)
 - AB Round-trip (single payload deployment and single payload retrieval)
 - A()B Round-trip (multi-payload deployment and single payload retrieval)
 - BA Sortie mission (round-trip of one payload with mission duration equal to Tug duration capability)

LAUNCI	4 SITE	ET	TR	Y	EAR:	1984
FUGHT		FLIGHT	PAYLUADS		PAYLOAD	
FUGHT NO.	OLBIT	MODE	UP	WEIGHT	DOWN	WEIGHT
			 	 		
144	 			ļ		
N/2	SA F	LIGHTS				
	SYNC. EQ	AB	8	3500	4	1800
2	<u> </u>	AB AB	8	3500	4	1800
3 4 5	••	AB	7	3000	3 3 3 2	2100
4	41	A(Z)B	4,1	2700	3	2100
5	↓ J.	AB	3	2100	3	2100
6	11	AB	7	900	2	1700
7	IAU.	A	9	1400		
8	6900 /55			6000		
a	13000 fps	A	10			
7	11	A	10	2000		
10	***		18	2000		
 			· · · · · · · · · · · · · · · · · · ·	;		
	1					
D	OD F	LIGHT	k			
1	1	A(2) B	2 2	1380	2	690
		AB	2,2 3b 15	1570	36	1570
3	1	AB	- 35	1970		1070
1 0		A(2)	17 17	1770	15	1970
9 5	<u> </u>		17,17 4a	4440		
3		A	42	3480		
7 3	ļ	A	4a	3480 3140		
7	 	A(2)8	3a,3a	3140	3a	1570
8		A.(2)B	4a 3ã,3a 3a,3a 8	3140	3a	1570
9		AB	8	2430	8	2430
10		19(3)	116,116,116	2550	_	-
						
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LAWNCA	SITE	ETR		Y	EAR	1985
FUGHT		FLIGHT	PAYLUADS		PAYLOAD	
NO.	OLBIT	MODE	UΡ	MEIGHT	DOWN	WEIGHT
T	SA F	LIGHTS				
	SYNC . EQ	AB	B	3500	1	900
2	31	AB	8	3500	2	1700
3	V	AB	7 7	3000	2	2100
3 4 5	n	AB	7	3000	4	1800
	'1	AB	6	2600	3	2100
6	"	AB	4	1800	5	2800
7	4.	A(2)B	1.2	2600	3	2100
8	4	48	3' 3	2100	3	2100
9	44	AB	3	2100	3	2100
10	٠,	AB	3	2100	3	2100
11	.,	A8	3	2100	3	2100
12		A8	3	2100	5	2800
/3	11	8			5	2800
14	30K ×16K29	AB	- //	1700	11	1700
	761	7,0	· · · · · · · · · · · · · · · · · · ·	1,00		,,,,,,
						
					 	
7	OD F	LIGHTS				
, ,		48		690	2	100 -
			2			690
2 3		AB	15	690	2	690
3		AB		1970	/5	1970
4		A	6	3480	<u> </u>	
		A	6	3480		3110
6		198	45	3480	46	3480
7		AB	46	3480	46	3480
<u>B</u>		/48 20	8	2430	8	2430
<u> </u>		AB	B	2430	8	2430
10		A(3)	110,110,110	2550	-	
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LAUNCI	4 SITE			EAR	1985			
FUGHT	A80	FLIGHT	PAYLUADS		PAYLOAD			
FUGHT NO.	OLBIT	MODE	UP	MEIGHT	DOWN	WEIGHT		
Į.								
NA	SA F	LIGHTS		 		<u> </u>		
/	VARIOUS	A(3)B		3800		-		
2	700/100		12,13,14	+	14	800		
3	500/99	AB AB	15	2000	15	2000		
	500 / 99		16	4500	16	4500		
4	500/99	AB	16	4500	16	4500		
1 6	777	48	16	4500	16	4500		
	500/99	A8	16	4500	16	4500		
				ļ				
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<u> </u>								
Do	D FL	1 GHTS						
<u>-</u>		A(2)	16,16	2250		-		
2		BA	12a	6000	122	6000		
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LAWNCA	SITE	ETR		Y	EAR.	1986
FUGHT NO.		FLIGHT	PAYLUADS		PAYLOAD	
NO.	OLBIT	MODE	UP	MEIGHT	DOWN	WEIGHT
						
NA	60 6	1101175				
	SW.EQ	LIGHTS	8	3		0 -
/		AB		3500	!	900
3	"	AB	8	3500	1	900
1 - 2	11	AB	3	2100	4	1800
4 5	11	AB	3	2100	2	1700
1	11	AB	3	2100	3	2100
<u></u>	41	AB	3	2100	3	2100
7 8	* **	AB	3	2100	3	2100
	11 204 ×1/4 /	AB		900	<u> </u>	1700
9	30H X16K /29	<u>B</u>			//	1700
10	I AU.	A(2)	9,9	2800	-	
	16,500 fps	A.KL	19	5500	-	<u> </u>
/2	24000 fps		22	2500	_	<u> </u>
13	18400 fps		23	5000	_	-
14	11	A-KL	23	5000	_	-
Do	DFL	16HTS				
1 /		AB	2.	690	2	690
Z		AB	2	690	2	690
3		AB	36	1570	36	1570
		A	17	2220	_	_
4		AB	3a	1570	34	1570
6		AB	34	1570	34	1570
7		AB	34	1570	34	1570
8		AB	34	1570	34	1570
9		AB	46	3480	46	3480
10		В		-	10	2745
11		AB	8	2430	8	2430
12		AB	8	2430	8	2430
		7,2				27,55
		 				
						
						
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-111 11		FLIGHT	PAYLUADS	т -	EAR.	
MA	OLBIT		1	WEIGHT	PAYLOAD	WEIGH
70.		MODE	UP		DOWN	VEIGH
	1					
Δ	ASA A	FLIGHT	\$	<u> </u>		
1	1900 XID 9/2_	R	_		12	2000
2	ZOKKIK/	В	_		13	1000
3	300 × 300 40	AB	14	800		800
72 3 4	700/100	AB	15	2000	14	2000
						
			ļ			
	00 1	FLIGHT:				
7		A(3) AB	5,5,5	2205		
 3	1		16	2610	16	2610
2 3 4 5	 	AB	110	2610	16	2610
	 	<u>8</u>	ļ <u> </u>		16	2610
	 	В	<u> </u>		16	2610
	 					
	 					
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FULUT			PAYLUADS		PAYLOAD	
NO.	OEBIT	MODE	UP	WEIGHT	DOWN	WEIGHT
7.0.		77002				
						
	ASA	FLIGH				
/	SYNC, EQ	AB	8	3500		900
2	11	AB	8	3500	3	2100
3		AB	7	3000	3	2100
4		AB	7	3000	3	2100
5		A(2)	6.4	4400	-	_
6		A(2)		3900	_	-
7		A(3)	4,3 3,3,1	5100	_	
8		A(2)	3.3	4200	-	
9		19(2)	3, 2	3800		
10	6900 /55		10	6000	-	
11	30016×/29	A	11	1700		 _
12	16500 fps	A-KL	19	5500		
13				5500		
	11 (00	A-KL	19		<u> </u>	
14	24000 tps	A-E	22	2500		-
			ļ			
D	OD F	LIGHTS				1
1		AB	2	690	2	690
2		AB	2	690	2	673
3		AB	36	1570	36	1570
		AB	15	1970	15	1970
5 6		A	6	3480	_	-
6		A	4a	3480	_	-
7		A	4a	3480	-	_
	 	A8	39	1570	34	1570
8		AB	34	1570	30	1570
10		AB	34	1570	34	1570
				1570	3a	1570
11		AB	3a	7370	· •	3480
12		3			4a	
13		B		2/2	40	3480
		AB	8	2430	8	2430
15		48	8	2430	8	2430
					-	-
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F (I/-NT	1	FLIGHT	PAYLUADS		EAR.	
<i>~</i> 0.	OLBIT		UP	WEIGHT	PAYLOAD DOWN	WEIGHT
~~~		MODE	UP		DOWN	02.01,
N	ASA P	A(3)B				
	VARIOUS	A(3)B	1213,14	3800	14	800
2	1700 /100	AR	15	2000	15	2000
3 4 5	500/99	8	-		16	4500
4	"	<i>B</i>	~	_	16	4500
5	H	8	_	_	16	4500
6	H	В	_		16	4500
						7300
	<u> </u>					
					ļ.—	
7	0D 1	FLI 61+7	<			
<u> </u>		A(3)	5,5,5	2205		
2		BA				6000
	 	DA	12a	6000	12a	6000
	 					
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LAWNLA	SITE	ETR		Y	EAR	1988
FUGHT		FLIGHT	PAYLUADS		PAYLOAD	
NO.	OLBIT	MODE	UP	MEIGHT	DOWN	WEIGHT
 					 	-
		-, 1 / 1/			 	
1079	SA F	LIGHTS		1		
	SYNC, FW	AB	8	3500	2	1700
٠2	41	AB	8	3500	4	1800
3 4 5	• (AB	7	3000	3	2100
4	• •	A(2)B	4,3	3900	4	1800
	٠,	A(3)	3,3,1 3,3,1 3,3	5100		
6	••	A(3)	331	5100		
7	ч	A(1) B	3.3	4200		900
8	1 Au	A	9	1400	_	_
9	30 K × 16 K	B	_	_	11	1700
7.	OD F	LIGHTS		1		
1		AB	2	690	2	690
2		A8	2	690	2	690
3		AB	36	1570	3 P	1570
4		AB	15	1970	15	1970
3 4 5		A	17	2220		
		AB	3a	1570	34	1570
9		AB	34	1570	34	1570
8		AB	3 4	1570	34	1570
9		AB	34	1570	34	1570
10		AB		3480	46	3480
11		AB	46	3480	45	3480
12		В		-	10	2745
/3		PB	8	2430	8	2430
14	 -	A8	8	2430	8	2430
15	-	A(3)	119,119,114	2550		
1-1-		77(3)	114,114,112	2370		
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	SITE		·	1988		
CUGHT	DERIT	FLIGHT		WEIGHT	PAYLOAD	
~ 0.	OLBIT	MODE	UP	WEIGHT	DOWN	WEIGHT
	000				ļ	
N	OSA 1	FLIGHT				
	700/100 1800 × 180/90	AB	15	2000	15	2000
	1800 × 180/90	8 8	_	_	12	2000
3	ZOK XIK 190	В	_			1000
4	300 × 3000/90	AB	14	0	/3	
	7 70	775		800	14	800
	h					
Z	OD A	FLIGHT AB AB	5	<u> </u>		
/		AR	11-	2610		2/.10
_/ 		10	16		16	2610
		70	16	2610	16	2610
						
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FLIGHT	H SITE		PAYLUADS	·T	PAYLOAD	1701
NO.	OLBIT	MODE	UP	WEIGHT		WEIGH
		11002			DOWN	100.07
1/0	SAF	1 1 / 1-		-		
10/7	SYNC. FQ	LIGHT AB		 		
	JINC. FU		8	3500	4	180
_2 _2	1,	AB	8	3500	3	2100
<u> </u>	11	A B	7 3000 3		3	2100
4	1,	A(2)B	23	3800		900
	,,	AB	5	2800	3	210
7	 	AB	5	2800	3	210
2	4	AB		2800	3	2100
9	30 K x 16 K/29	A(2)	1-13	3000		
10	13000 fps	A	<u> </u>	1700	-	-
11	13000 775	A	17	1000	-	ر
12	24000 fps		17	1000		_
/3	27000 fps	A-E	22	2500	-	_
	22000 fps	A-E	24	3300	_	_
14_	22000 +ps	A-E	24	3300	_	
			ļ			
7	D F	16475	ļ			
1	0 -		<u> </u>			
2		AB	2	690	2	690
3_		AB	2	690	2	690
		AB	15	1970	15	1970
5		AB	/7	2250	17	2220
6		B			17	2220
7		A	6	3480		
8		AB	46	3480	46	3480
9		<i>AB AB</i>	8	2430	8	2430
10			8	2430	В	2430
10		A(3)	116,116,116	2550		
						
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سود. مردم <u>س</u>		FLIGHT	PAUL NAME		Days A	
FLIGHT	OLBIT	l i		WEIGHT	PAYLOAD	WEIGHT
<i>NO</i> .		MODE	UP		DOWN	VE1011
NP.		LIGHTS				
	VARIOUS	A(3)B	12,13,14		14	800
2	VARIOUS	48	15	2000	14	2000
3	500/99	A(2)	16,16	9000		
2 3 4 5	"	A(2)	16,16	9000		
<u> </u>	''	A(2)	16,16	9000		
	DD 1	FLIGHT!	\$			
	 	19(3)	5,5,5	2202		
2 3 4	 	AB	16	2610	16	2610
<u></u>	 	AB	16 12a	6000	16 12a	2610
	 	BA	144	G000	16a	6000
		-	<u> </u>			<u> </u>
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	·	ETR		Υ.	1990		
FUGHT	OLBIT	FLIGHT	PAYLUADS		PAYLOAD		
~ 0.	06511	MODE	UP	MEIGHT	DOWN	WEIGHT	
1/	ASA A	-LIGHT	5				
	SYNC. EQ	AB	8	3500	 	900	
	11	AB	8	3500	 	900	
<u>2</u> 3		AB	6	2600	3		
<u> </u>	11	AB	6	2600		2100	
<u>4</u> 5	11	AB	·	}	3	2100	
4	"	AB	3	2100	3	2100	
7		+ 		2100	3	2100	
	. 4	48	3,	2100	3	2100	
$\frac{-8}{9}$		AB		900	2	1700	
		AB	1	900	. 4	1800	
10	1 AU	A(2)	9,9	2800			
	30K×16429	9		6000			
12	729	B				1700	
13	24000 fps	A-E	22	2500			
		161176					
<i>U</i>	OD FO	IGHTS		1.4		/	
		AB	. 2	690	2	690	
3	 	AB	2	690	2	690	
		AB	36	1570	36	1570	
4	 	A8	15	1970	_15	1970	
	 	AB		2220	/7	2220	
9	 	B		<u> </u>	/7	2220	
	 	9	49	3480			
8 9	 	A	44	3480			
		8			44	3480	
10		В			44	3480	
<i>!</i> !		AB	34	1570	3a	1570	
12		AB	34	1570	31	1570	
/3	-	AB	34	1570	3a	1570	
14		AB	34	1570	34	1570	
		<i>AB</i>	В	2430	8	2430	
16		A8	8	2430	8	2430	
17		A(3)	11c, 11c,11c	2550	-	-	
			···				
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LAUNCH SITE FUGHT OLBIT				Y	1990		
FLIGHT	100.T	FLIGHT	PAYLUADS	I	PAYLOAD		
<i>NO.</i>	005//	MODE	UP	WEIGHT	DOWN	WEIGHT	
NA	SA F.	IGHTS					
/	1800 x18c/90	8 B	_	_	12	2000	
	Wha! ~/ #	В	_	_		1000	
マ	300 × 3000/90	AB	14	800	13 14	800	
4	700/100	AB_	15	2 000	' 15	2000	
			<u> </u>				
\mathcal{D}_{i}	PD = P	LI GHT. AB)	P				
		/ -/ (3)	3,3,3	2205			
							
							
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2.3.2 Mission Model

The mission model for Option 2 is provided in the following table (Table 2-7). This is the mission model provided by the Government and is repeated here for completeness. The data shown on the table includes:

- 1. Mission Number (and DOD identification number for DOD missions)
- 2. Payload Weight (in pounds)
- 3. Payload Length and Diameter (in feet)
- 4. Number of mission per year (1980 through 1990) for both up payload and down payload traffic.
- 5. Total traffic for each payload
- 6. Subtotal yearly traffic for NASA and DOD
- 7. Total yearly traffic

TABLE 2-7

ı	M	18516	,	MO	DE	_	OF	アル) N	Z			1/	
		NEIGHT L D	80	81	82	83	84	85	86	87	88	<i>E</i> 9	90	TOTALS
1		900					Z/ /2	1/	1/2	1/	2/1	1/	2/2	10/10
2		1700 8 8					3	1/	/2	1	1	1	/	3/8
3		12 8					1/3	5/7	5/3	6/3	7/	2/5	3/5	29/27
4		1800				/	1/2	1/,	/	2/	1/2	1	7	5/8
5		12 14						3			/	3/		3 3
6		2600 128						1/		1/			2/	4/0
7		3000					1/	2/		2/	1/	1/		7/0
8		3500					2/	2/	2/	2	2/	2/	2	14/0
9		1400					1/		2/		1/		2	6/0
10		6000 12 8					1/			1/			1/	3/0
//		1700 8 8						1/1	/,	1/		1/		3/4
12		2000					/,	1/	/	1/	/,	1/	/	3 4
13		77						'/	/-	1	/	-/		3 4
14		800 10 5					//	1/	1/	1/1	1/	1/1	1/	7/7
15		2000 8 11					//	1/1	1/	1/1	1/	1/	1/	7/7
16		4500 11 13						4/4		4		6/		10/8
	_													

MISSION MODEL OPTION 2 (CONT.)

	NEIGHT L D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
	1000										2/		2
	2000					2/							2
	5500							1/	Z				3
	900					2/							2
	1600												0
	2500							1/	1/		1/	1/	4
	5000							2/					Z
	3300					2/					2/		4
	γ												
													· · · · · ·
				$\overline{}$									
	1												
													
	1												
NASA						17/1	22/20	16/	24/	16/	26/9	15/	136/90
	NASA	100 0 12 10 2000 12 10 5500 17 10 1600 15 10 2500 16 12 3300 17 12 17 12					1000 12 10 2 12 10 12 10 12 10 12 10 10	1000	17 22 16	1000	100 12 10 10 10 10 10 10	100 2 2 2 2 2 2 2 2 2	100 100

MISSION MODEL OPTION Z (CONT.)

	· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·											<u> </u>	.J
		NEIGHT L D	80	81	82	83	84	85	86	87	88	89	90	TOTALS
25	2	12 5					2/2	2/2	2/2	2/2	2/2	2/2	2/2	14/14
26	36	1570					1,		1/	1	17	/	1/	5/5
27	15	1970					1/	1/1		1/1	1/1	1/	1/	6/6
28	17	12 10					2/		1/		1/	1/2	1/2	64
29	126	2400												0/0
30	6	3480						2/		1/		1/		4/0
31	4a	3480					2/2			2/2			2/2	6/6
32	3a	1570			/		4/4		4/4	4/4	4/4		4/4	20/20
33	46	3480	/					2/2	1/		2/2	1/		6/6
34	10	2745					/				/1			0/3
3 5	8	2430					2/2	2/2	2/2	2/2	2/2	2/2	2/2	14/4
36	lla	96									3			3/0
37	116	950 96					3					3/		6/0
38	110	96						3/					3	6/0
39	5	735					3/		3/	3/		3/	3	15/0
40	16	261D 14.5 6.7						2/	2/4		2/2	2/2		8/3
41	12a	6000										1/		3/3
SUB-	DOD	<u> </u>					20/	15/ B	16/15	17/13	18/	17/11	19/14	122/39
TUTAL							37/27				34/25	43/20		258

2.4 PROGRAMMATICS INPUT DATA

The following data was provided as a basic input to the programmatics studies. The first chart summarizes the total flights and hardware requirements. The second group of tables show the flight schedules and hardware requirements as a function of year. There are five tables in the group, an overall summary, NASA ETR, NASA WTR, DOD ETR and DOD WTR. These charts represent the data requirested in NASA letter PD-TUG-P(028-74). The next chart shows the same flight requirements data in the format used by MDAC in the study. The final chart shows the usage of individual Tugs to accomplish the mission model.

At the top of the chart, the number of flights per year is shown and the number of Tug expendable flights. The number of Tugs required were established by first determining the number of Tugs necessary to accomplish the 1990 requirements and working backward from that point. The maximum number of flights any Tug can perform in a year is established first by summin the Tug ground turn-around time and the mission time which results in the minimum mission turn-around time. In Option 2 the ground turn-around time is 27.9 days and the average mission time is 3.3 days. The mission turn-around time is thus 31.2. The maximum number of cycles (flights) in a year is then 11.

Using this number and assuming that the maximum number of flights than an expended Tug can make in the year that it is expended is 6 (one-half the maximum turn-around in a year), the fleet of 4 for 1990 is established. Working backward from there it can be seen that in 1989 the three expendable requirements and the necessary Tugs in 1990 make up the inventory requirement. The resulting data show that to carry-out the operations a total of 9 Tugs are required during the program.

The major influence on fleet sizing is the number of expendable Tug missions required. If, for example, no expendable missions were required the required fleet size could be reduced to three vehicles.

CONFIGURATION OPTION 2

	REQUIRED	ACCOMPLISHED
DEPLOYMENTS	258	_248
RETRIEVALS	179	154
FLIGHT REQUIREMENTS (NASA/DOD)		
# ETR LAUNCHES # WTR LAUNCH # REFLIGHTS DUE TO LOSSES		88/89 29/16 3
FLIGHT COMPOSITION		
EXPENDABLES (E) TUG WITH BURNER II (KS ₁) TUG WITH POLARIS (KS ₂) TUG (BASIC) VEHICLE LOSSES/REFLIGHTS		5 211 3 (225)
FLEET SIZE REQUIREMENTS	•	
FOR OPERATIONS FOR RELIABILITY		<u>9</u> 3
TOTAL		
REQUIREMENT AT IOC (MIN)		2
FLIGHTS PER ARTICLE		24.5

TURNAROUND CYCLE 31.2 DAYS LAUNCH TO LAUNCH (CALENDAR DAYS)

FLIGHT SCHEDULE

TUG CONCEPT OPTION 2

LAUNCH SITE ETR/WTR AGENCY NASA/DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)**						20	32	32 (1) (1) 36 37	(1) 37	31	(3)	(1)	(3) (1) (6) 33 36 225
AUXILIARY STAGE								(3) (2)	(2)				(5)
DROP TANKS									,				
(OTHER)				*									
SHUTILE **				*		20	32	36	37	31	33	36	225

() DENOTES NUMBER EXPENDED.

25 payloads not accommodated in 1984 due to Tug availability REMARKS:

IVU test flight

^{**} Includes reflights due to reliability losses

FLIGHT SCHEDULE

TUG CONCEPT OPTION 2

LAUNCH SITE ETR AGENCY NASA

COMPANY MDAC

TOTAL	(9)	(5)			88
8	13 (1)				13
89	(3)			-	77
88	1				6
87	(f) #T	(2)			77
98	(1) (1) 14 14	(3) (2)			14 14
85	7.7				14
₹8	10				10
83					
82				*1	1*
81					
8					
79					
	TUG (BASIC)	AUXILIARY STAGE	DROP TANKS	(отнек)	SHUTTLE

() DENOTES NUMBER EXPENDED.

REMARKS: θ payloads not accommodated in 1984 due to Tug availability

IVU test flight

FLIGHT SCHEDULE

TUG CONCEPT OPTION 2

LAUNCH SITE ETR AGENCY DOD

COMPANY MDAC

	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
TUG (BASIC)						10	10	12	15	15	10	17	89
AUXILIARY STAGE													
DROP TANKS													
(other)	·												
SHUTTLE						10	10	12	15	15	10	17	89

REMARKS: θ payloads not accommodated in 1984 due to Tug availability () DENOTES NUMBER EXPENDED.

FLIGHT SCHEDULE

TUG CONCEPT OPTION 2

LAUNCH SITE WTR AGENCY NASA

COMPANY MDAC

	79	8	81	82	83	₩	85	98	87	88	89	8	TOTAL
TUG (BASIC)							9	₫	9	4	5	.#	29
AUXILIARY STAGE													
DROP TANKS													
(отнев)													
SHUTTLE							9	.27	9	<i>=</i>	5	#	29

() DENOTES NUMBER EXPENDED.

REMARKS: 6 payloads not accommodated in 1984 due to Tug availability

FLIGHT SCHEDULE

TUG CONCEPT OPTION 2

LAUNCH SITE WIR AGENCY DOD

COMPANY MDAC

TOTAL	16		,		16
06	-1				-г
89	. 				্ৰ
88	8				2
87	2				2
98	5				5
85	, N				2
1 8					
83					
82					
81	·				
80					
42	:				
	TUG (BASIC)	AUXILIARY STAGE	DROP TANKS	(отнек)	SHUTTLE

() DENOTES NUMBER EXPENDED.

REMARKS: 3 payloads not accommodated in 1984 due to Tug availability

FLIGHT REQUIREMENTS

OPTION 2

	80	81	82	83	84	85	98	87	88	89	66	TOTAL
ETR												
NASA					10	14	10	11	6	11	12	77
DOD					10	10	75	15	15	10	17	89
NASA EXPENDABLE					ı	1	1	-		٣	1	9
NASA KICK STAGE					Į.	L	3	2	ı	,	ı	5
DOD KICK STAGE					ì	1	-	-	_	ı	1	
WTR												
NASA					ı	9	77	9	7	2	্য	23
ססס					ı	2	. 5	2	5	-	Н	16
TOTAL					0	8	6	8	9	<u></u>	~	45
	-							1				1
	!		-								· - · ·	,
LEGIGHES / LOSSES			•						1	i	-	-

EQUAL USAGE SCHEDULE

OPTION 2

5 20	80	 81	82	83	84	85	86	87	88	89	96	TOTAL
(1) (1) (3) (1) (1) (2) (1) (2) (3) (1) (3) (1) (4) (4) (5) (6) (5) (4) (4) (7) (2) (6) (7) (7) (2) (2) (7) (4) (4) (6) (7					20	32	35	37	30	33	35	222
8 11 5 6 7 7 2 2 8 6 7 7 7 2 2 8 9 6 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9							(1)	(1)		(3)	(1)	(9)
8 11 5 6 7 11 4 2 2 2 10 8 3 4 4 7 2 2 2 10 8 3 4 4 4 4 4 6 10 8 3 4 4 6 9 10 8 9 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>												
7 11 \$\mathrm{\mu}\$ \$\mathrm{\mu}\$ \$\mathrm{\mu}\$ \$\mathrm{\mu}\$ \$\mu\$					ω	11	5					1 2
5 4 4 4 7 2 2 2					7	11	†₹	2				77
10 8 3 4 6 5 7 7 11 3 4 6 9 8 8 9 9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					5	η.	†	7	2	5		24
8 3 4 6 3 4 7 11 3 7 6 9 8 8 9						9	7	7	2	2		54
5 7 4 4 6 3 4 7 11 3 7 6 9 8 8 9 1 1							10	ω	m	4		25
3 4 7 11 3 7 6 9 8 8 9 1 1		·					5	7	.#	4	9	56
3 7 6 9 8 8 9 1 1					·			က	4	_	11	25
1 1								က	7	9	6	25
1 1									80	80	6	25
1 1												
1 1												
1	1											
1 1												
							1		H	era de la como de la c	7	3

2.5 SENSITIVITY STUDY DATA

2.5.1 Two Year Earlier IOC (December 1981)

A capture analysis was made to establish the fleet size requirements and flight schedule when the IOC is moved to December 1981. Identical ground rules to Option 2 were used to select mission combinations in the early years (see Section 2.1.2). The results are shown in the following four charts. The important impacts related to the capture analysis are that the fleet size increases by two vehicles and the total number of flights increases by 74 resulting in the accomplishment of 125 additional missions.

CONFIGURATION OPTION 2 (EARLY 10C)

	REQUIRED	ACCOMPLISHED
DEPLOYMENTS		
RETRIEVALS		
FLIGHT REQUIREMENTS (NASA/DOD)		
# ETR LAUNCHES # WTR LAUNCH # REFLIGHTS DUE TO LOSSES		$\frac{114/122}{39/21}$
FLIGHT COMPOSITION		
EXPENDABLES (E) TUG WITH BURNER II (KS ₁) TUG WITH POLARIS (KS ₂) TUG (BASIC) VEHICLE LOSSES/REFLIGHTS		8 - 7 281 3 (299)
FLEET SIZE REQUIREMENTS		
FOR OPERATIONS FOR RELIABILITY		
TOTAL		14
REQUIREMENT AT IOC (MIN) FLIGHTS PER ARTICLE		

[.] TURNAROUND CYCLE 31.2 DAYS LAUNCH TO LAUNCH (CALENDAR DAYS)

FLIGHT SCHEDULE

TUG CONCEPT OPTION 2 (EARLY IOC)

LAUNCH SITE FTR/WTR AGENCY NASA/DOD

COMPANY MDAC

	79	80	81	82	83	₹8	85	98	87	88	89	8	TOTAL
TUG (BASIC) **				19	35	70 70	33	(1)	(1) 38	30	(3)	<u> </u>	(8)
AUXILIARY STAGE						(2)		(3) (2)	(2)				(1)
DROP TANKS													
(OTHER)		*1											
SHUTTLE **		1*	n.	19	35 40		33	35	38	30	33	36	300

() DENOTES NUMBER EXPENDED.

REMARKS: 2 payloads not accommodated in 1982 due to Tug availability schedule

^{*} IVU test flight

^{**} Includes reflights due to reliability losses

FLIGHT REQUIREMENTS

OPTION 2 (EARLY 10C)

	80	81	82	83	84	85	98	87	88	89	96	TOTAL
ETR												
NASA			7	11	14	14	10	11	6	11	12	66
מסמ			75	7,7	17	10	12	15	15	10	17	122
NASA EXPENDABLE			ı	ı	N	ı	٦	1	ı	8	1	80
NASA KICK STAGE			_	1	2	1	3	2	-	_	1	7
DOD KICK STAGE			-	-	٠	-	ŧ	ı	-		1	0
TOTAL			19	52	35	₹ 7	56	29	24	24	30	236
WTR								•				
NASA			1	9	†	9	η	9	7	5	77	39
рор			1	ħ	1	2	5	2	2	17	٦	21
TOTAL			0	10	5	8	6	8	9	6	5	09
									·	,		
REFLIGHTS / LOSSES			enaet i de l'a l'agrico pida	emperature system on the system		1		1			7	3

EQUAL USAGE SCHEDULE

OPTION 2 (EARLY IOC)

	1		 1		·					·					
TOTAL	296	(8)	56	2ħ	28	28	28	28	28	28	25	56	25	_	Э
06	35	(1)								5	11	10	6		ч
89	33	(3)					2	2	†	4	7	9	8		
88	30						2	2	3	ф	4	7	8		
87	37	(1)				2	5	ग	10	8	5	3			1
98	35	(1)			2	1	ħ	10	11	7					
85	, K				8	8	9	10							7
84	01	(2)	9	9	6	10	6			,					
83	35		10	10	8	7									
82	19		10	8	1										
81															
80		χ.													
	NUMBER OF FLIGHTS	NUMBER OF EXPENDED TUGS	TUG ID 1	2	3	ħ	5	9	7	8	6	10	11		LOSSES

2.5.2 Engine Sensitivities

An estimate of the number of flights necessary to accomplish the Option 2 mission model was made. The basis of the estimate was a review of the Option 2 capture data and an estimate of the number of additional payload combinations which could be captured as a function of the vehicle capabilities. The vehicle capabilities considered are as follows:

Function	Category IV	ASE	Aerospike
Deploy	8,767	9,093	8,855
Retrieve	5,601	5,798	5,630
Round Trip	3,416	3,539	3,451

The resulting number of flights for each are (basic Option 2 requires 220):

Category IV	219
ASE	213
Aerospike	213

The fleet size does not change for any of the new engine concepts as compared with the basic Option 2 program.



SPACE TUG SYSTEMS STUDY (CRYOGENIC) SEPTEMBER DATA DUMP

VOLUME 4 Mission Accomplishment Book 3 Option 3

SEPTEMBER 1973

PREPARED BY: SPACE TUG STUDY TEAM

APPROVED BY:

L. Q. WESTMORELAND STUDY MANAGER

PREPARED FOR NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
UNDER CONTRACT NO. NAS8-29677

PREFACE

This study report for the Tug Program is submitted by the McDonnell Douglas Astronautics Company (MDAC) to the Government in partial response to Contract Number NAS8-29677.

The current results of this study contract are reported in eight volumes:

Volume 1 - Summary, Program Option 1

Volume 2 - Summary, Program Option 2

Volume 3 - Summary, Program Option 3

These three summary volumes present the highlights of the comprehensive data base generated by MDAC for evaluating each of the three program options. Each volume summarizes the applicable option configuration definition, Tug performance and capabilities, orbital and ground operations, programmatic and cost considerations, and sensitivity studies. The material contained in these three volumes is further summarized in the Data Dump Overview Briefing Manual.

This volume contains mission accomplishment analysis for each of the three program options and includes the tug system performance, mission capture, and fleet size analysis.

Volume 5 - Systems (3 Books)

This volume presents the indepth design, analysis, trade study, and sensitivity technical data for each of the configuration options and each of the Tug systems i.e., structures, thermal, avionics, and propulsion. Interface with the Shuttle and Tug payloads for each of the three options is defined.

Volume 6 - Operations (3 Books)

This volume presents the results of orbital and ground operations trades and optimization studies for each option in the form of operations descriptions, time lines, support requirements (GSE, manpower, networks, etc.), and resultant costs.

Volume 7 - Safety (3 Books)

This volume contains safety information and data for the Tug Program. Specific safety design criteria applicable to each option are determined and potential safety hazards common to all options are identified.

Volume 8 — Programmatics and Cost (3 Books)
This volume contains summary material on Tug Program manufacture, facilities,
vehicle test, schedules, cost, project management SR&T, and risk assessment for
each option studied.

These volumes contain the data required for the three options which were selected by the Government for this part of the study and are defined as:

- A. Option 1 is a direct development program (I.O.C.: Dec 1979). It emphasizes low DDT&E cost; the deployment requirement is 3500 pounds into geosynchronous orbit, it does not have retrieval capability, and it is designed for a 36-hour mission. MDAC has also prepared data for an alternative to Option 1 which deviates from certain requirements to achieve the lowest practicable DDT&E cost.
- B. Option 2 is also a direct development program (I.O.C.: 1983). It emphasizes total program cost effectiveness in addition to low DDT&E cost. The deployment requirement is 3500 pounds minimum into geosynchronous orbit and 3500 pounds minimum retrieval from geosynchronous orbit.
- C. Option 3 is a phased development program (I.O.C.: 1979 phased to I.O.C. 1983). It emphasizes minimum initial DDT&E cost and low total program cost. The initial Tug capability will deploy a minimum of

3500 pounds into geosynchronous orbit without retrieval capability, however, through phased development, it will acquire the added capability to retrieve 2200 pounds from geosynchronous orbit. The impact of increasing the retrieval capability to 3500 pounds is also provided.

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Section 1

PERFORMANCE

1.1 PERFORMANCE GROUND RULES

The payload performance was determined using the classical impulsive velocity equation. The velocities employed were based on the three dimensional finite burning trajectory analyses performed during Task 1. Since most of the missions in the mission model did not exceed three days duration, this figure was used for establishing performance capability even though subsystems are sized for six days. A detailed simulation of the basic geosynchronous deployment mission taking into account the actual losses associated with each engine start and the velocity contributed by propellant settling forces was used to determine an equivalent specific impulse penalty of 4 seconds which was then used for all missions.

For the geosynchronous transfer, a velocity of 13972 fps was used which represents the most unfavorable situation (from a performance point of view) of no low orbit phasing being required and the resulting injection to the transfer orbit being performed with only one burn instead of two. This velocity is approximately 80 fps greater than the most favorable two burn transfer injection. For the return, a velocity of 13920 fps was used.

Option 3 is a phased developed program that starts out similar to Option 1 and develops into a vehicle similar to Option 2 but retaining the Category I RL-10. Since the Option phases into a retrieval requirement, the tankage is sized for that mission even though it initially does not have the retrieval hardware.

The following weights and engine data were also employed in the performance computations:

	Initial	Final
Shuttle Capability	65,000	65,000
Ancillary equipment (to install Tug in the Orbiter Bay)	2,066	2,066
Vented during ascent	269	269
Tug gross weight at deployment from Orbiter Bay	62,665	62,665
Tug burnout weight (included FPR)	7,315	7,039
Propellant capacity (@5.5 EMR)	55,600	55 , 600

	Initial	Final	
Engine chilldown and propellant settling	61	61	
Vented in flight	57	5 7	
Attitude control propellant	93	93	
Engine	Category I RL-10		
Thrust	15	,000	
ISP (@ 5.5:1 EMR)	1414	1.8	

1.2 GEOSYNCHRONOUS PERFORMANCE

Based on the foregoing ground rules and data, the following geosynchronous orbit performance capabilities were determined at the nominal 5.5:1 EMR:

	Initial	Final
Deployment	3588 (3780)	4330 (4522)
Retrieval		2567
Round Trip	1335 (1366)	1611 (1642)

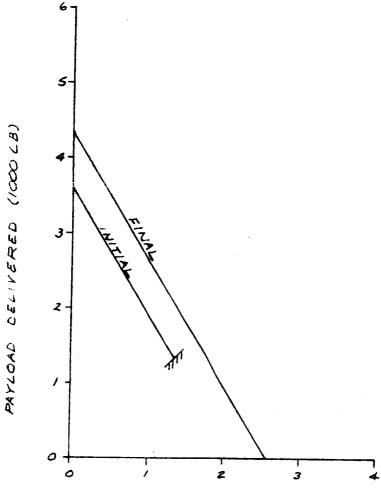
The deployment and round trip missions would require propellant to be off-loaded. By off-loading LOX only, an engine mixture ratio of 5.0 could be used yielding a two second improvement in Isp for deployment or 5.3 and 0.8 seconds for round trip and the payloads shown in parentheses. For mission of greater than 36 hours, the increase in on-orbit consumables must be corrected for using the factors given in Section 1.4.2. The final configuration would also have longer duration capability which would allow use of the lower velocity three burn transfer. But for a three day duration, the 150 lb added losses in geosynchronous orbit would leave a net difference of only 15 lb less deployment payload capability. Figure 1.2-1 shows how the payload delivery capability decreases as payload is returned.

1.3 PERFORMANCE ENVELOPE

Figures 1.3-1, -2 and -3 present the payload-velocity envelope for the Option 3I Tug starting from 28.5°, 55° and 90° inclinations, respectively. The corresponding data for Option 3f follows in f igures 1.3-4, -5, and -6. The significant variation with inclination reflects the Shuttle performance with launch azimuth. For missions below geosynchronous, specific impulse could be increased by off-loading LOX only initially to reduce the EMR to 5.0 and gain up to two seconds.



GEOSYNCHRONOUS PERFORMANCE CONFIGURATION OPTION 3



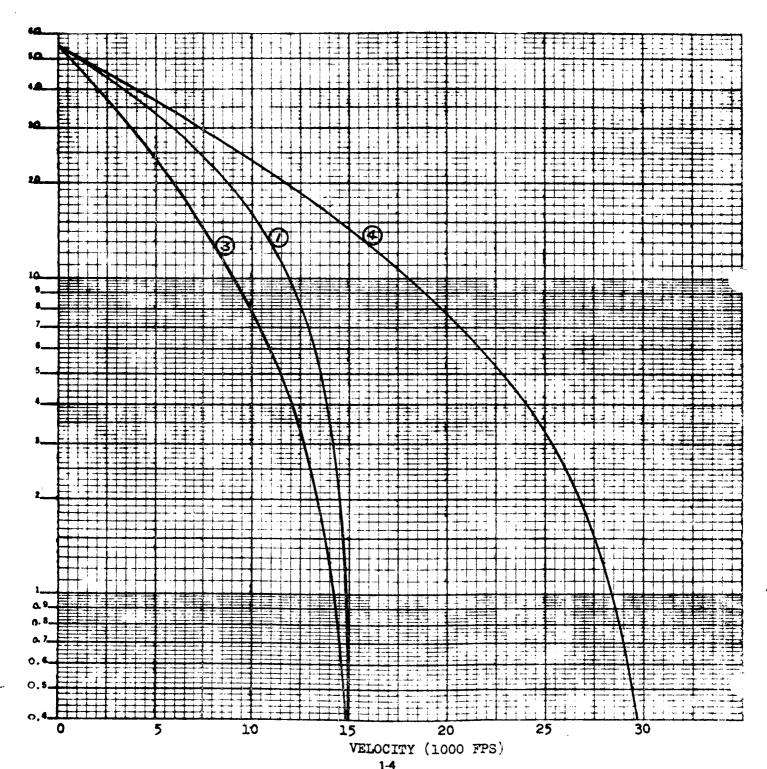
PAYLOAD RETRIEVED (1000 LB)

REVISED

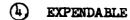
CONFIGURATION 3T

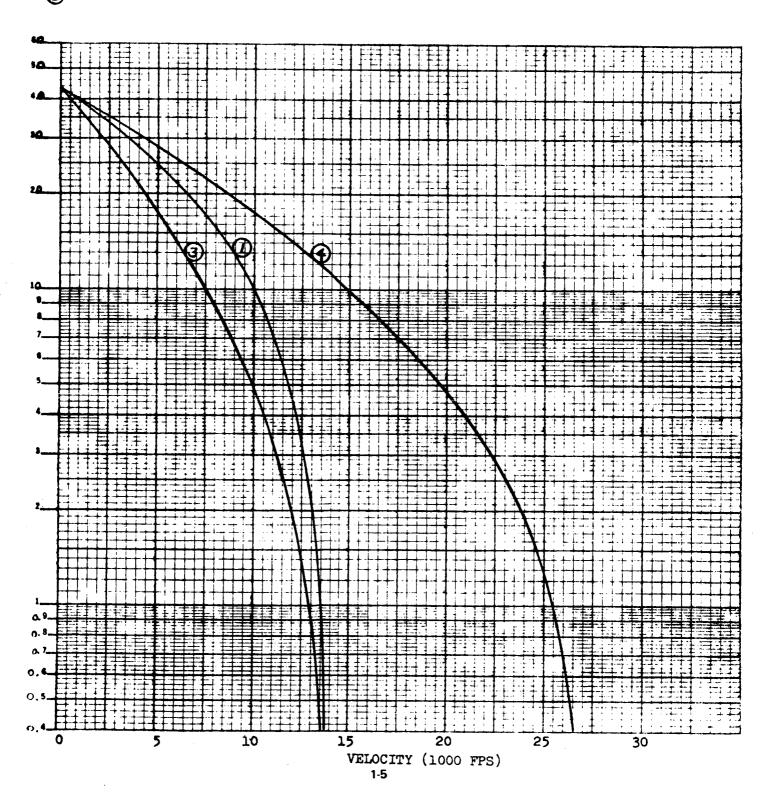
$$W_{BO} = \frac{7315}{441.8}$$
 $I_{NCL} = \frac{28.5}{28.5}$
 $I_{NCL} = \frac{28.5}{4}$
EXPENDABLE

- 1) DEPLOY
- (2) RETRIEVE
- (3) ROUND TRIP



- (1) DEPLOY
- (2) RETRIEVE
- (3) ROUND TRIP

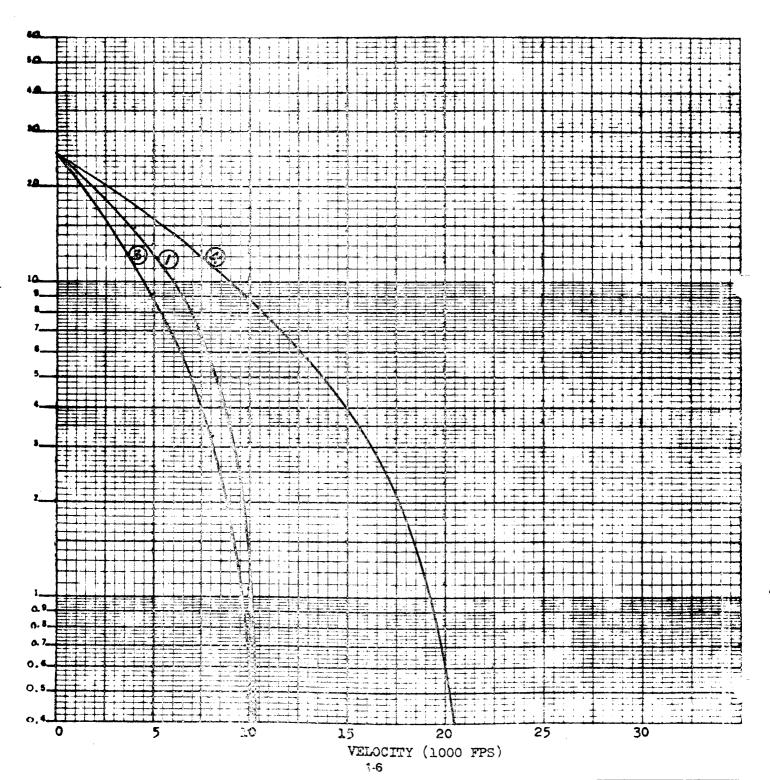




CONFIGURATION ___3_T

EXPENDABLE

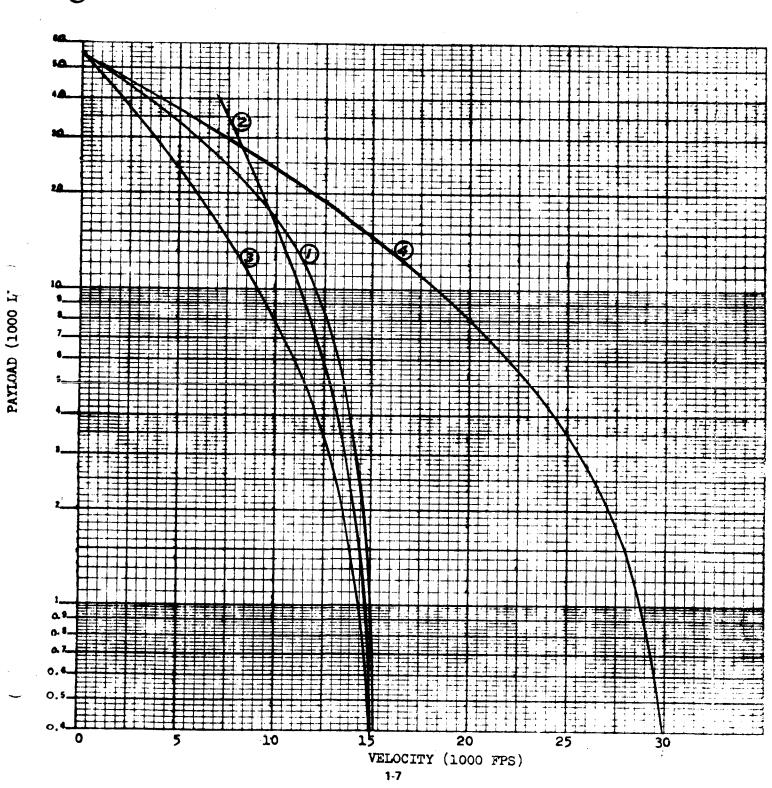
- 1 DEPLOY
- (2) RETRIEVE
- (3) ROUND TRIP



CONFIGURATION 3F

- EXPENDABLE

- DEPLOY
- RETRIEVE
- ROUND TRIP



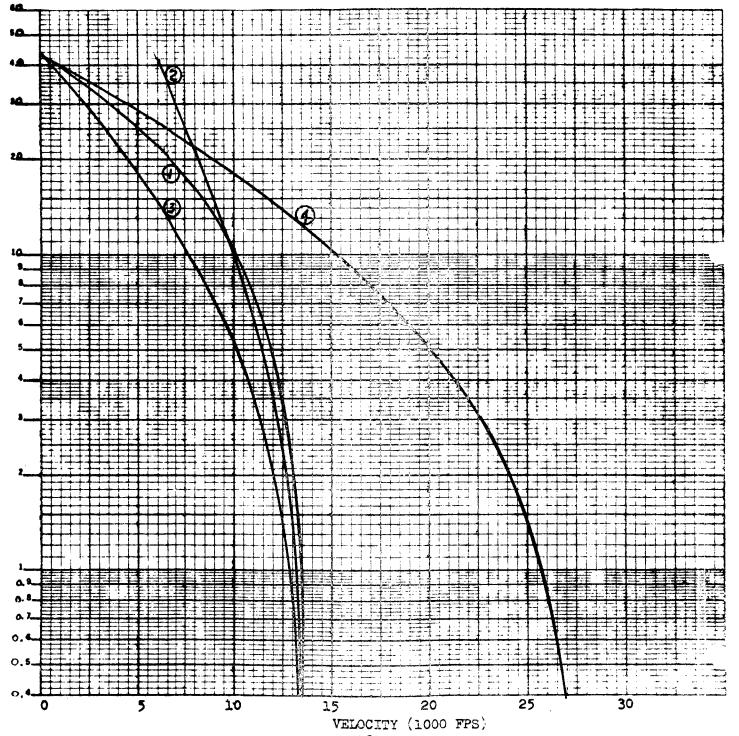
CONFIGURATION 3F

W_{BO} 7039

I_{SP} 4418

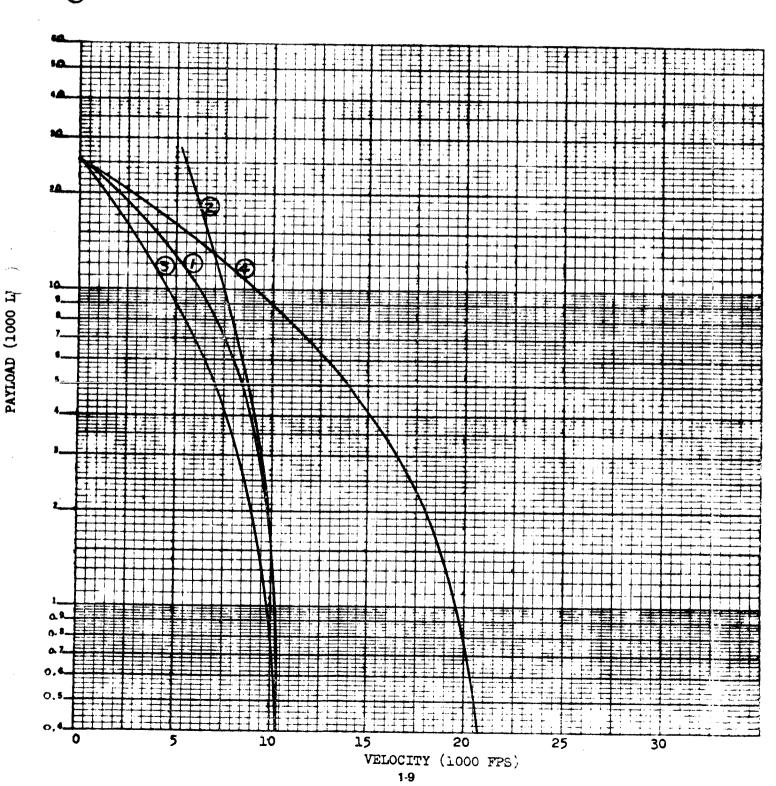
INCL 55° (4) EXPENDABLE

- 1 DEPLOY
- ② RETRIEVE
- ROUND TRIP



EXPENDABLE

- DEPLOY
- RETRIEVE
- ROUND TRIP



1.4 PERFORMANCE SENSITIVITIES

1.4.1 General Mission Trade Factors

The sensitivity of payload to the two principle performance factors, -Tug inert weight and Isp - are presented as a function of mission velocity in Figure 1.4-1.

1.4.2 Geosynchronous Trade Factors

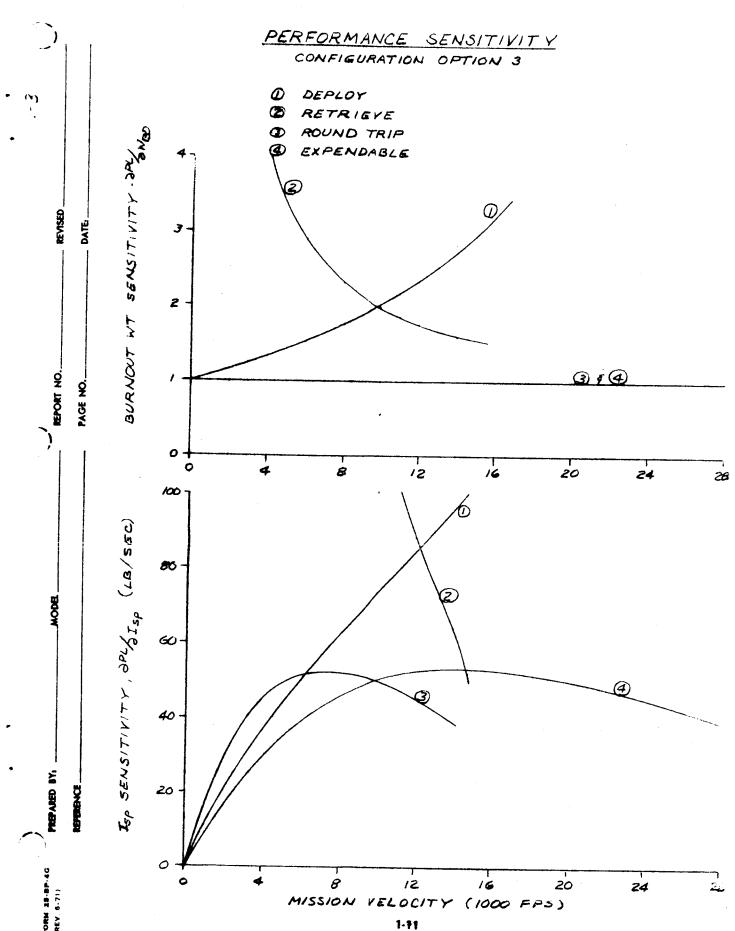
Specific trade factors for the geosynchronous missions are given in Table 1.4-1. The inert weight factor is applicable to any weight carried throughout the mission, such as structure and residual propellants. The gross weight factor can correct for variations in the Tug gross weight at first ignition such as Shuttle capability, ancillary equipment or propellants vented during ascent. These factors can be used for both initial and final configurations.

1.5 MISSION PERFORMANCE

The performance capability for each mission in the mission model was computed for each basic mission mode. The missions are defined in Table 1.5-1. Table 1.5-2 and -3 are computer printouts of the results for the initial and final configurations respectively and includes the velocities derived from Task I. The gross weight reflects the Shuttle delivery capability to the appropriate parking orbit inclinations. In several cases, alternate mission profiles are shown starting from different inclinations.

For the Option 3I vehicle, retrieval capabilities are shown even though the equipment necessary to physically pick up or attach such a payload is not included in the Tug weight shown. The capabilities with a kick stage were also determined for use in the mission capture analysis but are not shown simply to avoid classifying any data.





GEOSYNCHRONOUS MISSION TRADE FACTORS

	DEPLOY	RETRIEVE	ROUND TRIP
Burnout Weight: 3PL/3WBO	-2.67	-1.60	-1
Specific Impulse: oFL	95	64	39
Gross Weight: OFL OWS	•37	.22	.14
Orbit Loss: 37 3WoL	-1	60	37

Table 1.5-1
MISSION DESCRIPTIONS

Missio No.	n H _a x H _p (nmi)	Incl.	Remarks
1-8	19323	0	Synchronous orbit - single burn transfer orbit injection
1-8A	19323	0	Synchronous orbit - two burn transfer injection
1-8B	19323	0	Synchronous orbit - two burn transfer injection with 600 fps for multiple payload deployments
9	lau	Eclip.	2 I was a depast, menos
10	6900	55°	
10A	6900	55 °	Alternate - Shuttle launched into 28.5°
11	16Kx30K	20°	
12	180x1800	90°	
13	1 K x20K	90°	
13A	1Kx20K	90°	ETR Alternate - Shuttle launched into 28.5°
13B	1Kx20K	90°	ETR Alternate - Shuttle launched into 55°
14	300 x 3000	90°	and the familiary
15	700	100°	
16	500	99.2°	
17-8	Interplane	tary	ΔV - 13000
19			16500
20		,	23000
21-2			24000
23			18400
24	·		22000
D11	58 K	0,30,60	
D1 0	860x21K	63.4	Shuttle launch into 63.4° WTR
Dloa	860x21K	63.4	ETR Alternate - Shuttle launched into 55°
D5	750	99°	
D3	13.6кж25К	60°	Shuttle launched into 60° WTR
D3A	13.6x25K	60°	ETR Alternate - Shuttle launched into 55°
D12	300	1040	
D16	400	98.3°	

CØNFI GURA	TIØN ØPT 3I	STAGE WT	-7315.00 ISI	P=441.80 DEL	ISP=4.00
MISSIØN	GRØSS-WT V-ØUT	PL-RØUND V-BACK	PL-DEPLØY	PL-RETRI EVE	PL-EXPEND
1-8	62665•00 13972•00	1335•76 13920•00	3588 • 51	2127.81	15925•11
1-8A	62665•00 13890•00	1386•27 13920•00	3724.20	2208•27	16060.79
1-8B	62665•00 14190•00	1023.42 14220.00	28 08 • 60	1610•15	15568 • 22
9	62665•00 14160•00	964•44 14350•00	2671.27	1509 • 40	15617.01
10	50665•00 9700•00	5465•99 9700•00	10882.80	10981.61	18131•98
10A	62665•00 12760•00	2922•37 12760•00	7230.27	4904.86	18013-35
11	62665•00 12450•00	3383.05 12450.00	8187.84	5765•07	18576-96
12	32665.00 2285.00	16299 • 57 228 5 • 00	19170.24	108848.31	20458 • 55
13	32665•00 8400•00	2595•66 8400•00	4712.36	5 778 • 68	10677.55
13A	62665•00 13460•00	1953.80 13460.00	5080.21	3174.80	16785.40
13B	50665.00 11200.00	3014.24 11200.00	6675•72	5495.66	15561 • 43
14	32665•00 3600•00	12277.56 3600.00	15852.87	54438 • 61	17983.04
15	26665.00 1700.00	13631.58 1700.00	15380 • 14	119901.62	16318.46
16	26665.00 1120.00	15429.58 1120.00	16706.52	201869.75	17311.90
17-8	62665.00 13140.00	2309 • 20 13250 • 00	5915.44	3787.85	17339 • 18
19	62665.00	•00	•00	•00	11778.93
	16740.00	17210.00			

20	62665 •00 23550 • 00	•00 24500•00	•00	•00	4459 • 11
21-2	62665•00 24600•00	•00 25500•00	•00	•00	3613.35
23	62665•00 18720•00	•00 19550•00	•00	•00	9275.04
24	62665.00 22500.00	•00 23500•00	•00	•00	5370.34
D11	62665•00 13930•00	1355•44 13930•00	3643.95	2158.24	15994.50
D10	48 665.00 8 500.00	7241.95 8500.00	13241•24	15983.95	19301.04
DIOA	50665.00 9800.00	5285.80 9800.00	10599.03	10544.33	17951.97
D5	26665•00 1770•00	13424 • 42 1770 • 00	15221.87	113686.00	16201.30
D3	48 665•00 1 18 50•00	1731.80 11850.00	4016.62	3044•46	13667.44
D3A	50665.00 11920.00	2010•46 11920•00	4686.13	3521.09	14421.47
D12	26665.00 500.00	17522.61 500.00	18155•77	502460.00	18420.09
D16	26665.00 850.00	16318 • 48 850 • 00	17333.52	278 667 • 12	17788.52

CONFIGURATION OPT 3F STAGE WT=7039.00 ISP=441.80 DELISP=4.00

MISSIØN	GRØSS-WT V-ØUT	PL-RØUND V-BACK	PL-DEPLØY	PL-RETRI EVE	PL-EXPEND
1-8	62665.00 13972.00	1611•76 13920•00	4329 • 98	2567.46	16201-11
1-8A	62665.00 13890.00	1662•27 13920•00	4465•66	2647•92	16336•79
1-8B	62665•00 14190•00	1299 • 42 14220 • 00	3566.03	2044•38	15844.22
9	62665•00 14160•00	1240•44 14350•00	3435•72	1941-36	15893.01
10	50665.00 9700.00	5741.99 9700.00	11432.32	11536-12	18407.98
10A	62665.00 12760.00	3198.37 12760.00	7913•12	5368 • 09	18289.35
1 1	62665•00 12450•00	3659 • 05 12450 • 00	8855•83	6235•41	18852•96
12	32665•00 2285•00	16575.57 2285.00	19494•85	110691•44	20734-55
13	32665.00 8400.00	2871•66 8400•00	5213.43	6393•13	10953.55
13A	62665.00 13460.00	2229.80 13460.00	5797.86	3623•29	17061-40
13B	50665.00 11200.00	3290.24 11200.00	7286•98	5998 • 87	15837.43
14	32665•00 3600•00	12553.56 3600.00	1 6209 • 24	55662•39	18259•04
15	26665•00 1700•00	13907.58 1700.00	15691•55	122329•31	16594.46
16	26665.00 1120.00	15705.58 1120.00	17005•36	205480-75	17587.90
17-8	62665.00 13140.00	258 5 • 20 1 3 2 5 0 • 0 0	6622•46	4240 • 58	17615-18
19	62665.00 16740.00	.00 17210.00	•00	•00	12054-93

20	62665.00 23550.00	•00 24500•00	•00	•00	4735.11
21-2	62665.00	•00	•00	•00	3889.35
	24600.00	25500.00			
23	62665.00	•00	•00	•00	9551.04
	18720.00	19550.00		<u>.</u>	>331.04
24	62665.00	•00	•00	•00	5646.34
	22500.00	23500.00			
D11	62665.00 13930.00	1631 • 44 13930 • 00	4385.95	2597.71	16270.50
	10700100	.3730.00			
D10	48665.00	7517.95	13745.88	16593.12	19577.04
	8 500 • 00	8 500 • 00		3 3 3 3 3 3 3 3	.,,,,,,,
DIOA	50665.00	5561 -80	11152.46	11094.91	18227.97
	9800.00	9800.00			
D5	26665.00	13700 - 42	15534.83	116023.31	16477.30
	1770.00	1770.00			
D3	48 665.00 118 50.00	2007-80	4656.75	3529 • 66	13943.44
	11050.00	11850.00			
D3A	50665.00	2286.46	5329 • 45	4004.47	14697.47
	11920.00	11920.00	3027 743	4004147	14077447
D12	26665.00	17798 • 61	18441.75	510374.31	18696.09
	500.00	500.00			
D16	26665•00	16594.48	17626.68	283380.31	19044 ==
	850.00	8 50 • 00	11020100	203300•31	18064.52

Section 2

CAPTURE ANALYSIS - OPTION 3

2.1 FLIGHT SUMMARY

The data provided in Section 2.1.1 represents a summary of the mission captured by the Option 3 program based upon all constraints of the system potential (Tug capability) and the program schedule (Tug and related support systems availability). Section 2.1.2 identified the missions, from the Option Mission Model, which are not captured by the program and also includes the rationale for their exclusion.

2.1.1 Flight Summary Data

Tables 2-1 through 2-5 present the number of flights per year for each of the flight modes used in Option 3. Also shown are the total Shuttle and Tug flights and the number of missions identified as requirements in the Option Mission Model. On Table 2-1 the number of missions accomplished is identified.

The mission modes used in this option are defined as follows:

Deploy

- Single Payload The deployment of one payload to one location and velocity vector and return of the Tug to the Shuttle.
- Multi 2 Payload The deployment of two payloads to one location and velocity vector and return of the Tug to the Shuttle.
- Multi 3 Payloads The deployment of three payloads to one location and velocity vector and return to the Shuttle.
- Kick Stage Large The deployment of one or more payloads to one location and velocity vector using a Polaris kick stage as a second stage to the Tug. The kick stage is expended and the Tug returns to the Shuttle.
- Expendable The deployment of one payload to one location and velocity vector. The Tug is expended.

Retrieval

Single Payload - The retrieval of one payload from one location and return to the Shuttle.

Round Trip

Deploy 1/Retrieve 1 - Deploy one payload at one location and velocity vector (maneuver 60° phase angle position for synchronous equatorial mission between deployment and retrieval), retrieve one payload and return to the Shuttle.

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- Deploy Multi/Retrieve 1 Deploy one payload at one location and velocity vector, maneuver to a second position and velocity vector and deploy second payload, if three satellites are to be deployed, maneuver to a third position and velocity vector and deploy third satellite and retrieve another satellite at that position (for synchronous equatorial mission each maneuver shall be 60° phase angle).
- Sortie Carry a payload to one orbital location, remain in that orbit for 130 hours (22 hours for initial configuration) and return the payload to the Shuttle.

FLIGHT SUMMARY-OPTION TOTAL-OPTION 3

						Calendar	1	Year					
뚀	Flight Mode	80	81	82	83	₹8	85	98	87	88	89	8	Total
	Shutt1e	Ω	77	22	36	44	41	41	710	37	14.1	710	366
Totals	Tug	3	21	22	36	77	41	41	10	37	141	04	366
	Deploy												
	Single Payload	2	21	18	25	12	14		10	7	12	97	138
	Multi2 Payloads	1		2	8		н	7	5	7	77	-	27
	Multi3 Payloads				٦	2	7	7	7	н	2	2	11
	Kick-Stage Mode			2	Н	-8		M	a				10
Tug	Expendabl.e					2		7	-7		٣	7	. 8
Flight Distribution													
	Retrieve												
	Single Payload					12	6	12	8	6	8	11	69
	Round Trip												
	Deploy 1/Retrieve 1					13	14	91	11	16	10	15	95
	Deploy Multi/Retrieve l					7	1		7		ri		7
	Sortie				7		щ		7				77
	Total												
	Deploy	34	23	77	84	37	37	32	1,1	34	43	34	387
Mission Model	Retrieve	0	0	0	1	25	25	28	27	25	20	56	171
	Total	34	23	54	64	62	62	09	62	59	63	09	558
Accomplishment	Total	3	21	77	617	62	62	09	62	59	63	9	525

FLIGHT SUMMARY-NASA-OPTION 3

Colondor Veer	Calendar lear	81 82 83 84 85 86 87 88 89 90 Total	14 12 19 26 28 24 24 19 25 21 41	14 12 19 26 28 24 24 19 25 22 216		14 10 15 7 11 6 6 5 9 6 91	h 1 5 h h 1 20		2 3 2 9	2 1 1 3 1 8			10 8 9 7 7 5 8 54		h 8 h 2 3 3 6 30	1 1 1 h			16 12 23 17 22 16 24 16 26 15 201	0 0 0 14 17 13 10 10 9 14 87	
		Flight Mode	G) F1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1	Totals	Deploy	Single Payload	Multi2 Payloads	Multi3 Payloads	Kick-Stage Mode	Tug Expendable	Flight	Distribution Retrieve	Single Payload	Round Trip	Deploy 1/Retrieve 1	Deploy Multi/Retrieve 1	Sortie	Total	Deploy	Mission Model Retrieve	The state of the s

FLIGHT SUMMARY-DOD-OPTION 3

						Calendar		Year					
	Flight Mode	80	81	82	83	78	85	986	87	88	89	96	Total
	Shuttle	0	7	10	17	18	13	17	16	18	16	18	150
Totals	Tug	0	7	10	17	18	13	17	16	18	16	18	150
	Deploy												
	Single Payload		<u>-</u>	80	10	5	3	1	7	2	<u>س</u>	7	147
	Multi2 Payloads			7	#								
	Multi3 Payloads				1	2	П	7	7	-	2	2]]
	Kick-Stage Mode				7			T					-
Tug	Expendabl.e								ŀ		1		\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \
right Distribution												 -	
	Retrieve												
	Single Payload					2		8	77	2	<u>س</u>	m	15
							-					+-	
	Round Trip												
	Deploy 1/Retrieve 1					6	9	12	6	13	1	0	65
	Deploy Multi/Retrieve 1		:				-	-			-	+	
	Sortie							-	-1		-	T	17
	Total							T	╁			T	
	Deploy	20	7	12	25	20	15	16	17	18	17	19	186
Wission Model	Retrieve	0	0	0	7	11	8	15	17	15	11	12	48
								-	-				

FLIGHT SUMMARY—ETR-OPTION 3

						Calendar		Year					
Ē,	Flight Mode	80	81	82	83	48	85	98	87	88	68	96	Total
	Shuttle	3	21	22	28	39	33	32	32	33	32	35	308
Totals	Tug	3	21	22	28	39	33	32	32	31	32	35	308
	Deploy												
	Single Payload	5	17	18	25	12	7,7	7	10	7	12	10	138
	Multi2 Payloads	7		2	N				5	7	7	7	17
	Multi3 Payloads					г •	F			 	7	7	
	Kick-Stage Mode			7	7	2		'n	a				10
Tug	Expendable					2		П			8		8
Fight Distribution						-							
	Retrieve												
.	Single Payload					10	6	8	7	7	8	6	55
	Round Trip												
	Deploy 1/Retrieve 1					11	6	12	10	12	7	13	ηL
	Deploy Multi/Retrieve 1				-	7	-						7
	Sortie						ļ	\vdash					
	Total												
7	Deploy	34	23	5₽	32	32	23	25	33	30	27	59	312
Mission Model	Retrieve	0	0	0	ó	23	18	20	17	19	15	22	131

FLIGHT SUMMARY-WIR-OPTION 3

						Calendar	1	Year					
, 1	Flight Mode	8	81	82	83	78		98	87	88	80	8	Total
	Shuttle	0	0	0	ω	5	8	6	8	9	6	, 5	58
Totals	Tug	0	0	0	8	5	8	6	80	9	6	5	58
	Deploy												
	Single Payload												
\$ ~ ₁	Multi2 Payloads			,	9		-				m		10
	Multi3 Payloads				٦	7		٦	н		7	7	9
	Kick-Stage Mode												
Tug	Expendable												T
Flight Distribution													
	Retrieve												
	Single Payload					2		7	7	2		2	14
	Round Trip												
	Deploy 1/Retrieve 1					2	5	7	7	7	Ж	2	21
	Deploy Multi/Retrieve 1						7		7				8
	Sortie				н		77			-	-		77
	Total						-						
1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	Deploy	0	0	0	16	5	14	2-	8	7	16	5	75
MISSION MODEL	Retrieve	0	0	0	П	2	7	8	7	9	5	†7	04

2.1.2 Missions Not Captured

The availability of the Shuttle in 1980 of 3 Tug flights and in 1981 of 21 flights constrains the Tug mission assignments in these years. The following rationale was used to select payloads for each of the Tug flights in those years.

1980

- 1. The first flight would be a simple flight with a light payload (although large enough to warrant use of the STS). NASA Mission 4 was selected.
- 2. The second flight would be a simple flight with a heavy payload. NASA Mission 8 was selected.
- 3. The third flight would be one of the most numerous. NASA Mission 3 was selected.

1981

 Delete missions which could be performed with current expendable launch vehicles. NASA Mission 1 (two payloads) were deleted.

The following missions were not performed in 1980:

NA	SA	DOD	
MISSION	NUMBER OF PAYLOADS	MISSION	NUMBER OF PAYLOADS
1	2	2	2
2	1	3ъ	1
3	2	15	1
6	1	3a	4
7	ı	4ъ	1
8	1	8	2
9	1	lla	3
11	1	116	3
17	1	lle	3

Two NASA Mission 1 payloads were not performed in 1981.

All other missions, both NASA and DOD, were performed as required.

2.2 ADDITIONAL PAYLOAD CAPTURE

M

The capability of the Option 3 Tug to capture missions beyond the Option 3 mission model is illustrated in Table 2-6, which indicates the mode in which the Option 3 Tug can capture various missions. The missions identified are those which are contained in the total mission model, but are excluded in the Option 3 mission model.

NASA missions 17 and 18 can be deployed in the normal Tug reusable deployment mode. NASA missions 19, 22, 23, and 24 can be performed by expending the Tug. NASA mission 20 can be accomplished in a Tug reusable mode using a kick stage (Polaris Kick stage). NASA mission 5 can be retrieved in a normal retrieval mode after the orbital energy has been reduced. The reduction of the orbital energy is accomplished by using the excess capability in another mission to bring the payload part way back. The mode is called the "nudge" mode. NASA missions 6, 7, 8, and 10 require two flights to accomplish, as they are just beyond the estimated performance maximum for the "nudge" mode (see Book 2 Section 2.2.).

DOD mission 12B cannot be performed by the Option 3 Tug due to payload round trip weight capability being less than 2400 pounds.

OPTION 3

ADDITIONAL PAYLOAD CAPTURE POTENTIAL

ATION 3	2	SORTIE	50 fps 3	its 3	1ts 10	its 7	its 2											25	1	
CANDIDATE CONFIGURATION 3	TUG MODE	RETRIEVE	Nudge 1160 fps	Two Flights	Two Flights	Two Flights	Two Flights													<u></u>
AND IDA								3	2	3	†1	#	2	7			22			
ນ		DEPLOY						Normal	Normal	Expendable	Kick Stage	Expendable	Expendable	Expendable						
N MODE	SORTIE		1	ı	l	ı	I .	ŧ	ı	1	ı	ı	t	1	5		1	1	5	
OPTION MISSION MODE	RETRIEVE		3	3	10	7	2	ı	1	1	ı	ı	١		•		1	25	1	52
1 [DEPLOY		1	1	1	ı	ı	3	2	3	4	7	2	7	1		22	3	•	
MISSIONS EXCLUDED FROM	DESIGNATION	I.M	2800	2000	5500	0001	9500	2000	3300	7900	1500	4000	0099	4400	2400		DEPLOY	RETRIEVE	SORTIE	TOTAL
MISSIO	DESIC	I.D. #	N 5	N 6	N 7	N 8	N 10	N 17	N 18	N 19	N 20	N 22	N 23	N 24	D 12b			TADAT.		

D = DODN = NASA

2.3 FLIGHT DATA

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2.3.1 Flight-by-Flight Mission Assignments

The following table (Tables 2-6) present the flight by flight mission assignments for each of the Tug flights for each year of the program. ETR and WTR launches are shown on separate pages.

Each chart shows the following data:

Flight Number - numbering of flights which is arbitrary and has no relation flight sequence or schedule.

Orbit - Mission orbit defined by altitude and inclination. In the case of interplanetary missions the mission velocity is given.

Flight Mode - the flight mode the Tug will operate to perform the mission. Flight modes used by the Option 1 Tug are defined as follows:

- A single payload deployment
- A() multi-payload deployment
- A-KL payload deployment using kick stage (planetary mission)
- A-E payload deployment expending the Tug (planetary mission)
- AB Round-trip (single payload deployment and single payload retrieval)
- A()B Round-trip (multi-payload deployment and single payload retrieval)
- BA Sortie mission (round-trip of one payload with mission duration equal to Tug duration capability)
- I Mission performed with initial configuration (all missions not so designated are performed with final configuration).

CIGHT		FLIGHT MODE	PAYLUAD	<u> </u>	FAR:	1786
NO.	OEBIT	MODE	UP	WEIGHT	DOWN	WEIGH
						
NA	SAF	CLIGHT Q A A	-\$		 	
	SYNC. E	Q A	# <u>8</u> 3	1800	 	
3	"	A	8	3500		 _
_3	"1	A	3	2100		
			1			
			1			
			1			
				1		
			 	 		
				†		
			<u> </u>	 		
			 	 		
				 		
				 		
						
			 	 		
		I		 		
				 		
				 		
				 		
				 		
						·
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				-		
						
						·
						
						
T						

LAUNC,	H SITE	ET		Y	EAR:	1981
FUGHT	ORBIT	FLIGHT	PAYLUADS	İ	PAYLOAD	
<i>№</i> 0.	0.0017	MODE	UP	MEIGHT	DOWN	WEIGHT
						
NA	SA F	LIGHT	3			
	SYNC . EQ	A	8	3500		
2	"	A	8 7	3000	_	
3	4	A	4	1800	 	
3 4 5	10	A	3	2100		
5	20	A	3	2100		
7	11	A	3	2100	-	
	"	A	3	2100		
8	1,	A	3 3 3	2100	-	
9	,,	A A	3	2100	_	
10	"/	A	3	2100	-	
	,,	A	2	1700	_	
12	"	A A	2	1700	_	
13	400 155	A	10	6000	-	
14	BOKAILK/29	A	//	1700	-	

	OD A	LIGHT	5			
		A	2	690		
2 3			2	690		
3		A	44	3480	_	_
4		A	40	3480	_	-
		_ A	10	2745		-
6		A		2430		
7		A	8	2430		
					· .	
						
						w
						
						
						
						· · · · · · · · · · · · · · · · · · ·
						
				<u> </u>		

P	UNCH	SITE	ET		YEAR:		1982
FL	IGHT	OLBIT	FLIGHT	TAYLUADS	WEIGHT	PAYLOAD	
^	10.	OCSII	MODE	UP	WEIGHT	DOWN	WEIGHT
	NA:	SA F	LIGHTS				
	/	SYNC. P.Q	A	8	3500	~	_
	2	"	A	7	3000		
	3	1,	A	7	3000	_	_
	4	<i>u</i>	A	6	2600	_	
	<u>4</u> .5	1,	A		2100	_	
	4	''	A	3 3	2100	_	
	7	1,	A	3	2100		
	8	1.	A		900		
	4		13	 	900	_	
	10	1 AU	<i>H</i>)	9	1400		
	11	23,000 fps	A.KL	20	900		
	12	11	A-KL	20	900		
		 	13-12	- 20	700		
				 	 		
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			<u></u>	<u> </u>	ļ	ļ	ļ
		D F	LIGHT.	<u> </u>	 	 	<u> </u>
		<u> </u>	A	7	690	<u> </u>	
	2	ļ	A	2	690		 -
	3		A	36	1570		
	9		A	15	1970	_	_
	5		A(2)	30,30	3140	_	
	6		A(2)	3a 3a	3140		_
	7		A	43	3480	-	_
	B	 	A	4 6	3480		T
	9		A	8	2430	 	
	10	 	A	3	2430		
		 	 			 	
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FUGHT	SITE	FLIGHT	TR PAYLOADS	YY	EAR	1983
NO.	OLBIT	MODE	UP	WEIGHT	PAYLOAD	WEIGH
	 	1100E	-		DOWN	V2.01
NA	5.00	1 1 1				
1	SYNC, EQ	41547				
	SPAC, EGA	·	8	3500		
<u>2</u> 3		A	8_	3500		
4		A	7	3000		
<u>,</u>		A	7	3000		~
·3		A	5 5 5	1800	_	-
		A	5	1800	_	. ~
<u>7</u> &		A		1800	-	-
<u> 3</u>		A	4	1800		-
	·.	A	3	1300		-
10		A		2100		-
- //	H	A	3	2100		
/2		A	3	2100		-
/3		<u>A</u>	2	1700		
14	9 9 10 17 10 2	<i>F</i>)	1	900	-	
15	SOKAILK/79	A	11	1700		
D¢	DF	IGHTS				
-/			2	690	_	~
2		A	2_	650	_	` <u> </u>
3		A	36	1570		-
4		A	15	1970		-
5		A	17	2200	-	~
6		A	17	:200	_	-
7		A(2)	3a,3a	3140	-	~
8		A(z)	30,30	3140		_
9		A	46	3480	-	
10		13	10	2745	-	
//		A	8	2430	_	
/2		A	B Ila,ila,ila	2430		
/3		19 (3)·KL	Ila, Ila, Ila	2550		-
	· · · · · · · · · · · · · · · · · · ·					
						
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				<u>-</u>		· · · · · · · · · · · · · · · · · · ·
						· · · · · · · · · · · · · · · · · · ·
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FUGNT NO. 0281T FUGNT PAYLOADS WEIGHT DOWN WEIGHT NO. 1 VARIOUS A(2) 12,13 2000 2 VARIOUS A(2) 14,15 2600 2 VARIOUS A(2) 16,16 9000 2 VARIOUS A(2) 16,16 9000 2 VARIOUS A(2) 16,16 9000	1	LAUNCA	SITE	WT	ア	Y	EAR.	1983
MASA FLIGHTS / VARIOUS A(2) 12,13 3000		FUGHT.	028,7	FLIGHT	PAYLOADS UP	WEIGHT	PAYLONS	WEIGHT
1 VARIOUS A(2) 12,13 3005	Ì							
1 VARIOUS A(2) 12,13 3005		M	35A F	LIGHTS				
2 VARIOUS A(2) 14,15 2800 3, 500/99 A(2) 16,16 9000 4 " A(2) 16,16 9000 DOD FLIGHTS 1 A(3) 5,5 5 2205 2 A(2) 16,16 5220 3 A(2) 16,16 5220		/	NARMUS	A(2)	12,13	3000		_
$\frac{3}{4}$ $\frac{500}{99}$ $\frac{A(2)}{A(2)}$ $\frac{16}{16}$ $\frac{9000}{9000}$	1	2	VAICIOUS	A(2)	14.15	2800	Mining and	_
DOD FLIGHTS 1 A(3) 5,5 5 2205 A(2) 16,16 5220			500 /99	A(2)	16,16	9000		-
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	-	4		A(2)	16,16	9000		·
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	-							
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$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	t	D	DD F	LIGHTS				
2 A(2) 16,16 5220					555	2205		
3 A(2) 16,16 5220		Z						-
4 BA 12a 6000 12a 6000	L	3		A(2)	16,16			
		4.		B A	12a	6000	129	6000
	-							
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LIGHT		FLIGHT	PAYLUADS		EAR:	198
NO.	ORBIT	1	(WEIGHT	PAYLOAD	WEIGH
// U .		MODE	UP		DOWN	02.01
	<u> </u>					
N	\$5 <i>A</i>	FLIGHT				
	SYNCEQ	I-A	8	3500		
3	"	I-A	8	3500		
_3	h	IA	7	3000		
4		A	4	1800		
	11	В	_	-	4	1800
6	••	В	_	_	4	1800
7	••	AB	3	2100	1	900
8	**	3	_	-	3	2100
9	•1	B		-	3	2100
10	11	В	_	_	3	2100
//	11	В	_	-	2	1700
12	11	8	_	_	2	1700
13	۱,	В		_	2	1700
14	ts	A(2) B	1,1	1800	1	900
15	1 94.	I- A	9	1400	_	· · ·
16	6900 / 55		10	6000		
17	13000 fps	I-A	18	2000	_	
18	4	I-A	18	2000		_
19	23000 fps	I . A.KL	20	900	-	
20	tı .	I-A-KL	20	900		_
21	22000 fps		24	3300	_	
22	1,	I.A-E	24	3300	-	
			1 =	3300		
		· · · · · · · · · · · · · · · · · · ·				·
Do	DF	LIGHTS				
1		AB	2	690	2	690
2		AB	2	690	2	690
3		1313	36	1570	36	1570
4		I-A	15	1970	-	
<u> </u>		B	\ \frac{1}{-}	-	15	1970
6		I- A	/7	2200		- , , , ,
フ		I-A	17	2200	_	_
8		T- A	40	3480	-	-
9		r-A	44	3480		
10		AB	3a.	1570	3a	1570
11		48	34	1570	34	1570
12		AB	3a	1570	34	1570
13		AB	32	1570	34	1570
14		AB B AB	_		10	2745
15		AR	8	2430	8	2430
16		AB	8	2430	8	2430
17		A(3)	11 6,116 116	2550	<u></u>	- T T T T
		~(3)	מון פיי, יים	2390		
	·	<u></u>				
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-111 15	1	FLIGHT	PAYLUADS		PAYLOAD	
NO.	OLBIT	1	UP	WEIGHT	DOWN	WEIGHT
<i>~</i> 0.		MODE	UF		DOWN	
						ļ
N/	9517 1. 1800 × 180/90	LIGHT	3			
	1800 × 180/90	<u>B</u>			12	2000
2	20 K x 1 K/90	B			13	1000
3	300×3× 90	AB	14	800	14	800
2 3 4	700/100	AB AB	15	2000	15	2000
	1					
			 	†	1	
					———	
			 		 	
	h 5	11175	 	 	 	
<i>\bullet</i>		LIGHTS	5, 5, 5	2205		<u> </u>
	 	I-A(3)	3, 3, 3	2203	-	
	-			 		
	 		 			
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PUNCI	4 SITE	ET			EAR	1985
LIGHT	A 8 8 . T	FLIGHT	PAYLOADS		PAYLOAD	
~ 0.	OLBIT	MODE	UP	WEIGHT	DOWN	WEIGHT
NI	SA F	LIGHTS				
	SYNC, EQ	I-A	8	3500		_
7	n	I.A	0	3500		
2 3	•	I-A	8			
4	1 ,			3000		
5	 	I-A	7	3000		
		T-A	6 2	2600		
6 7	*	AB B	2	1700		900
	"				3	2100
3		AB		900	2_	1700
9	11	I-A	3	2100		_
10	61	I-A	3	2100	_	_
	ır	I-9	3	2100		_
12	11	I-A	3	2100		~
/3	11	I.A	3 3 3 3	2100		
14	,,			2100	3	710-
15		B	<u> </u>		3 3 3 3	2100
	'1	2			3	2100
16	· · · · · · · · · · · · · · · · · · ·	8 8			3	2100
					3	2100
18		В		_	3	2100
19	/1	В	-	-	3	2100
20	/.	I.A	4	1800	_	_
21	11	В	-	-	4	1800
22	30 K x 16 15/29	AB	11	1700	11	1700
DOD	FLIG					
1		AB	2	690	2	690
7		AB	2	690	2	690
3		A	15	1970		
4		B	_	-	15	1970
5		I-A	6	3480		_
4		I-A	6	3480		-
7		AB	45	3480 3480	46	3480
8		AB	41	3480		
9		08	70	2/120	4b B	3480
		AB	46 8 8	2430	<i>D</i>	2430
10		AB	<u> </u>	2430	8	2430
		A(3)	11e, 11e, 11c	2550		
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FULLT		FLIGHT	PAYLUADS		PAYLOAD	
NA	OLBIT	MODE	UP	WEIGHT	DOWN	WEIGHT
,,,,,		77002	-		3000	
4/0	() [-, , , , , , , , , , , , , , , , , ,				
	SA F	LIGHT	12 12 14	20-0	14	0
~_/	700/100	A(3) B AB	12,13,14	3800 2000	15	2000
3	500/99	48 48	16	4500	16	4500
4	"	AB		4500	16	4500
4	4,	AB	16	4500	16	4500
6	h	AB	16	4500	16	4500
·······			1			,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
7						
	D F	14475	1,			
/_ 		A(2)	16,14.	5220		6000
		BA	12a	6000	12a	6000
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LAUNCH	SITE	三丁	R	Y	EAR.	1986
FUGHT NO.		FLIGHT	PAYLUADS		PAYLOAD	
NO.	OLBIT	MODE	UP	WEIGHT	DOWN	WEIGHT
						
						
NAS		IGHTS				
		I-A	8	3500		ļ
2	41	T. A	8	3500		ļ
3	''	I-19	3	2100		ļ
4	٠,	I-A	3	2100		
5	٠,	I-A	3	2100		
6	1,	I-A	3	2100		
7	1,	AB	3 3 3	2100	,	900
8	1,	В	_	_	3	2100
<u>8</u> 9		В		_	3	2100
10	••	В	 		3	2100
11	1,	В			ک	1700
			 		2	1700
/2	11	B		 		1800
	''		 	-	4	
14	"	AB	1	900		900
15	IAU	I-A(2)	9,9	2800		
16	16,500 fps	I-A-KL	19	5500	-	-
17	24000 tps	J-A-E	22	2500		-
18	18400 595	I-A-KL	23	5000		-
19	84	I-A-KL	23	5000	-	_
20	30 K416K29	В	_	_	11	1700
Do	D FL	IGHTS				
1		48	2_	690	~	690
7		AB	ے	690	2	690
3		A8	36	1570	3 <i>b</i>	1570
4	†	I-A	17	2200		_
5	 	AB	32	1570	3a	1570
- 3 6	 	A8	3a	1570	3a	1570
7.	 	A8	34	1570	32	1570
	 		3a	1570	34	1570
8	 	A8				_
9	 	AB	46	3480	45	3480
10	ļ	AB	8	2430	8	2430
	ļ	В		 -	10	2745
12	 	AB.	8	2430	8	2430
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		WT		Y.	FAR:	1986
FLIGHT	028,7	FLIGHT		WEIGHT	PAYLOAD	1110 C 12 13 T
~ 0.	02011	MODE	UP	W = 10 H ;	DOWN	WEIGHT
NA	SA F 1800×180/90 20Kx14/90	LIGHT	5			
1	1800×180/90	B		_	12	2000
2 3	20Kx1K/90	В	_	_	13	1000
3	300 3000/4	AB	14	800	14	800
4	700/100	PB	14	2000	15	2000
	7 7 7 9 9	775				T
						-
			·			
D	D F	LIGHTS			1	<u> </u>
,		LIEHTS I-A(3)	555	2205		-
2		AB	1 1/	2610	16	2610
3 4 5		AB	16	2610	16	2610
4		AB B		-	16	2610
		В			16	2610
				† · · · · · · · · · · · · · · · · · · ·		
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		-	 	+	 	+
	 	 		 	 	
	 	 	 			

FUGHT	1	FLIGHT	PAYLUADS	ļ	PAYLOAD	I
~O.	OLBIT	MODE	UP	WEIGHT	DOWN	WEIGH.
		11000			.50WA	<u> </u>
NA.	to T	1010		··		
_/٧/7	SYNK.EG	16HTS	8	3500		
	A A	A				
2 3 4 5 6 7	.,	A	8 7	3500 3000	<u> </u>	
1	 	A	7	3000		
~~~	"	A(2)	4.3			<u> </u>
<u> </u>			6,2	4300		
7		A(2) A(2)	7,7	3600		<u> </u>
B	,,	B	3,3	7200	-	7.00
9	,,	8	ļ		3 3 3	2100
10	<u> </u>	B			3	2100
11	<del> </del>	9(1)	1 1	3000		2100
12	1 11	A(2)	3, 1	3000		<del></del>
/3	<del> </del>	AB	3 3	4200	<del></del>	-
14	6900 /55		3	2100	1	900
15	304×16×/29	I.A	/0	6000		-
16	16500 fgs		11	1700		
17	16500 275	I-A-KL I-A-KL	19	5500		_
18	24000 fps	I-A-E	19	5500	ļ	<del></del>
	27000 775	1-71-2		2500	<del>-</del>	
				l		
						<del></del>
Do	D FL	16HTS	· · · · · · · · · · · · · · · · · · ·			
/		AB	2	690	2	690
2		148	2	690	2	690
3		AB	36	1570	36	1570
4		A	15	1970	-	_
5		В	-	_	15	1970
6		A	6	3480	_	_
7_		A	40	3480	_	_
8		A	49	3480		_
9		AB	3a	1570	3a	1570
10		AB	34	1570	34	1570
11		AB	34	1570	3a	1570
/2		48	34	1570	34	1570
/3		AB	В	2430	8	2430
		AB	8 8	2430	E	2430
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LAUNCH	SITE	WT	R		EAR!	
FUGHT NO.	OLBIT		PAYLOADS	WEIGHT	PAYLOAD	WEIGHT
<i>№0.</i>		MODE	UP		DOWN	
						<del> </del>
NA	5/9 F	LIGHT	12 12 14	2000	14	200
1 2	700 /99	A(3) B AB	12,13,14	3800 2000	15	2000
2	500/99	B	/3	-	16	4500
3 4 5	1,	В		<u> </u>	16	4500
5	43	В		_	16	4500
6	4	8	_	_	16	4500
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			ļ <u>.</u>	<del> </del>		
			<del> </del>	<u> </u>	-	
Do	D =L	GHTS	<u> </u>	<del> </del>		<del></del>
1		A(3)	5,5,5	2205	_	_
2		A(3) BA	124	6000	12a	6000
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LAUNCA	SITE				EAR.	1988
FUGHT NO.	APR.T	FLIGHT	PAYLUADS		PAYLOAD	
<b>₩</b> 0.	005//	MODE	UP	MEIGHT	DOWN	MEIGHT
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NA:	KA 6	1011	<del> </del>			ļ
	SYNC, EQ	IGHTS	<del> </del>		! 	
2		<u> </u>	8	3500		
		A	8	3500		
3	11	A	7	3000	_	
4 5	11	AB	1	900	1	900
5	,,	A(2)	1,3	3000	_	
47	11	A(2)	3,4	3900		
7	1,	В			4	1800
8	.,	В		-	4	
9	,,	В				1800
10	11	0()	<del></del>	-/-	2	1700
		A(2)	2,3	4200		
		A(2)	1 3, 3	4200	-	
13	*1	_A	3, 3 3, 3 3	2100		
	1,	B			3	2100
14	1 Au	A	9	1400	_	_
15	30 × × 16 × 29		_		11	1700
	1 -1		1			1100
			†			
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		AB	2	690		690
2		<u> 48</u>	2	690	2	690
3		AB	36	1570	3 b	1570
¥ 5		<u> </u>	15	1970		-
5		B	_	-	15	1970
6		A	17	2200	-	
7		AB	34	1570	34	1570
8		AB	34	1570	3a	1570
9	1	AB	34	1570	34	
10		AB	34	1570	77	1570
11				1570 3480	34	1570
		48	43	3480	46	3480 3480
12		AB	46	3480	43	3480
/3		B			10	2745
14		777	3	2430	8	2430
		AB	8	2430	8	2430
16		A(3)	119,110,110	2550	_	
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NA	SA F	LIGHT. B	5				
	1800× 180/90 20K×1K/90	В		_	/2	2000	
2	ZDKXIK/AL	R			/3	1000	
3	300×3000/90	AB	14	800	14	800	
4	700/100	48	15	2000	15	2000	
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		FLIGHT	2 PAYLUADS		PAYLOAD	·
NO.	ORBIT	MINDE	ייט פיט	WEIGHT	DOWN	WEIGH.
70.		MADE	0,		DOWN	<del> </del>
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NA	SA /	LISHTS		! 		
	SYNC. ED	A	8	3500	-	
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3	<b>A</b>	A	7	3000	<u> </u>	_
3 4 5	И	A(2)	5,2	3500		_
5_	11	AB	'S S	1800	1	900
6	4,	A	5	1800	_	I.
7	) t	AR	/	900	4	1800
8	1,	A	3	2100	-	-
<u>g</u> 9	11	A B	3 3	2100	_	-
10	b _k	В	_		3	2100
11	14	В	-	_	3	2100
12	4	В	-	_	3	2100
13	11	8		_	3	2100
14		12		_	3 3 3 3	2100
15	30 K x 16 K/29	A	11	1700		_
16	13000 505	A	i	1000	_	_
17	11	A	17	1000		<del> </del>
18	24000 fg 5		22	2500	<del>  -</del>	<del> </del>
19	55000 102	A-E A-E	24	3300		
20	22000 505	A-E	24	3300	_	
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750	D FL	16 <i>HT</i> S				
		48 48	2	690	<u> </u>	490
<u></u>		745	15	690	2	690
2 3 4 5 6 7		A		1970	<del>                                     </del>	125
4	<del> </del>	<u>B</u>			15	1970
5		A	17	2250		
<u> </u>		8 B			17	2200
		B		-	17	2200
8 9		A	6	3480		-
		198	46	3480	46	3480
10		A8	8	2430	8	2430
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//		AB	8	2430	8	2430
//		AB A(3)	116,116,116	2430 2550	8	2436
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		<del></del>	אור, לנויקלוו מור, לנויקלוו	2430	8 -	2436
		<del></del>	(16,116) (16,116)	2430	8 -	2437
		<del></del>	(16,116) (16,116)	2430	8 -	2436
		<del></del>	(16, 116) (16, 116)	2430	8 -	2436
		<del></del>	(16,116) (16,116)	2430	8 -	243 0

FUGAT		FLIGHT	PAYLUADS		PAYLOAD	
NO.	08817	MODE	UΡ	WEIGHT	DOWN	WEIGHT
A/	0<0	FLIGH	<del></del> <			
	VARIOUS	A(3) B	12 13 14	3800	14/	800
<del></del>	700/100	AR	12,13,14	2000	14	2000
<del>- </del> -	500/60	0(1)	16,16	6000	15	2000
2 3 4	1, 79	A(2)	16,16	9000		
- 7	4	19(2)	16,16	9000		
<u> </u>			70,70	7000		
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D	OD F	LIGHTS				† <del></del>
1		A(3)	5,5,5	2205	_	
2		4B	16	2610	16	2610
2 3 4		ЯВ	16	2610	16	2610
4		BA	12a	6000	12a	6000
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FUGHT		FLIGHT	PAYLUADS	ł	PAYLOAD	I	
NO.	DEBIT	MODE	UP	WEIGHT	DOWN	WEIGH	
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1/0	SA F		<u> </u>	ļ	ļ		
	SYNC. EQ	LIGHT					
<del>'</del>		A	8	3500			
2 3 4 5	1,	A	8	3500			
<u>3</u>				2600			
	<del>                                     </del>	A	6	2600			
	"	48		900	4	1800	
67	"	DB .	<del> </del>	900	2	1700	
- (	"	AB	3 3	2100		900	
8	1 11	AB	3	2100	ļ <u>l</u>	900	
	"	<i>A</i> B B	3	2100			
10	- '-	ਨ	<del>                                     </del>		3	2100	
	••	<u> </u>	<u> </u>		3	2100	
/2	11	В	<del></del>		3	2100	
/3	"	В	<del></del>		3 3 3 3	2100	
14	"	В			3	2100	
15	1 Au	A(2)	9,9	2800			
16	6900/55 30K×16K/29	_A	10	6000			
17	300 2 10 12 29	В				1700	
18	24000 fps	A.E	22	2500	-	_	
DO	D E	IGHTS					
1		AB	2	690	2	690	
2_		AB	2	690		690	
3		AB	36	1570	2 3 b	1570	
4		14	15	1970		7270	
5		B		-	15	1970	
6		A	17	2200			
		Ŕ	17		17	2200	
7		<i>А</i> В В	<del> </del>		17	2700	
9		A	44	3480		2200	
10		A	46	3480			
11		48	4a 3a	1570	34	1570	
12		AB	39	1570	34	1570	
/3		AR	30	1570 1570	36	1520	
13		<i>AB AB</i>	34 34	1570	34 34	1570	
15		AB	B	2430	B	2430	
16		AB	8	2430	8	2430	
17		A(3)	11c,11c,11c	2550		<del>- / 5 0</del>	
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FUGHT	DEBIT	FLIGHT		WEIGHT	PAYLOAD			
NO.	00577	MODE	UP	WEIGHI	DOWN	MEIGH		
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	70	5		<b>—</b>	12	2000		
3	20 KX1 K/90	ELICHT B B A3 A3 A8	14	_	13	1000		
3	300 × 3 K/90	AB	14	800	14	800		
4	700/100	AB	15	2000	15	2000		
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D:	DD F	LIGHTS						
		16HTS A(3)	5, 5, 5	2205	_			
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#### 2.3.2 Mission Model

The mission model for Option 3 is provided in the following table (Table 2-7). This is the mission model provided by the Government and is repeated here for completeness. The data shown on the table includes:

- 1. Mission Number (and DOD identification number for DOD missions)
- 2. Payload Weight (in pounds)
- 3. Payload Length and Diameter (in feet)
- 4. Number of mission per year (1980 through 1990) for both up payload and down payload traffic.
- 5. Total traffic for each payload
- 6. Subtotal yearly traffic for NASA and DOD
- 7. Total yearly traffic

#### MISSION MODEL OPTION 3

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	NEIGHT 1- D	80	છે !	82	83	84	ઇડ	86	87	88	89	90	TOTALS
1	106	2	2/	2/	1/	2/2	1/1	1/2	1/1	2/1	1/	2/2	17/10
2	1700	1/	2/	/	/	3	1/1	/2	1	/!	1/	/1	7/3
3	2100	3	7/	3/	3/	1/3	5/7	5/3	6/3	7/1	² / ₅	3/5	45/27
4	 1800	1/	1/		2/	1/z	1/1	/	2/	1/2	/	/	4/8
5	1800				3/						3/		60
6	2600 12 3	1/		1/			1/		1/			2/	6/0
7	3000	1/	1	2/	2/	1/	2/		2/	/	/		13/0
B	3500	2	1/	1/	2/	2/	2/	2/	2/	2/	2/	2./	20/0
9	1400	1/	/	1/	/	1/		2/		1/		2/	3/0
10	12 8	/	1/	/		1/			1/				70
11	1700	1/	1/		1		1/1		1/	/	/	1	64
12	2000				1	1	1	/	1/	/	1/	1	1/4
/3	1000	/	/		1/	/	1/	/	1/	/	1/	1	4 4
14	800	/			1/	1	1/	1/	1/	1/1	1/	1/	3/7
15	2000	1	/		1/	1/	1/	1	1	1	1/	1	3/7
16	4500				4/		4/4		4		6/		14/3
		/											

MISSION MODEL OPTION 3 (CONT.)

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	_	L	IGHT D	180	181	82	83	84	85	86	87	88	<i>E</i> 9	90	TOTALS
17	7	12	10							/			2/	/	3
18	3	12	10		1/			2		/				/	2
19	)	20	12		1/	1./		1		1/	2/		/	/	3
20	,		10		1/	2/	/	2/		/					4
21		16 15	10	/		/	/	/							0
22			12					/		1/	1		1/	1/	4
23		50 17	12		/					2/				_	2
24			12			/		2					2		4
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SUB-	NASA			14/0	16/0	12/2		17/	22/	16/2			26/1		2.01
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<del></del> -		NEIGHT	80	انخ	82	83	В4	<b>८</b> ८	86	87	88	€9	90	TOTALS
		L D	2/	2/	2/	2/	z/	z/	2/	2/	2/	2/	2/	22
25	2	12. 5	/	_	7		/2	/2	1/2	/2	1/2	/2	1	3
26	36	1570	1/		/	/	1		//	1/	//		1	9
27	15	1970	1/		1/	//	1	1		1/1	1/1	1/	1/1	/6
28	17	2200				2/	2/		/		1/	/2	2	
29	126	24/00												00
30	6	3480	2 /			1/		2/	1/	1/			1/2	40
31	4a	3480		2/		1/	2/	1/		2			2/4/	30
32	30.	1570			4	4/	4/4		4/4	4 /	4 4		4	20
33	46	3430 25 15			2	1/	1/	1/2	- /	1/	7/2	- /		10/6
34	10	2745		1/		1	1/			1/		1/	/	3
35	8	2430	0 2	2	2	2	12/3	2 2	$\frac{2}{2}$	$\frac{2}{2}$	2/	$\frac{2}{2}$	$\frac{2}{2}$	22/4
36		350		1		3		1/	1/		3			9/0
37		950		1			3					$\sqrt{3}$		90
38	110	850		1	1			3	1				/ 3	9/0
39	i 5	73.		1		3	3		3	3		/ 3	3	13/0
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41	120	1000	20	1	1	1			1		1//		1/	4 4
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TOTA			34	23	X		137	25/	25 /	28	11/34 21/	25/		26 171

#### 2.4 PROGRAMMATICS INPUT DATA

The following data was provided as a basic input to the programmatics studies. The first chart summarizes the total flights and hardware requirements. The second group of tables show the flight schedules and hardware requirements as a function of year. There are five tables in the group, an overall summary, NASA ETR, NASA WTR, DOD ETR and DOD WTR. These charts represent the data requested in NASA letter PD-TUG-P(028-74). The next chart shows the same flight requirements data in the format used by MDAC in the study. The final chart shows the usage of individual Tugs to accomplish the mission model. At the top of the chart, the number of flights per year is shown and the number of Tug expendable flights. The number of Tugs required were established by first determining the number of Tugs necessary to accomplish the 1990 requirements and working backward from that point.

### CONFIGURATION OPTION 3

	REQUIRED	ACCOMPLISHED
DEPLOYMENTS RETRIEVALS	<u>387</u> 171	<u>354</u> 
FLIGHT REQUIREMENTS (NASA/DOD)  # ETR LAUNCHES  # WTR LAUNCH  # REFLIGHTS DUE TO LOSSES	1NITIAL 82/38 4/6	97/91 33/15 3
EXPENDABLES (E)  TUG WITH BURNER II (KS ₁ )  TUG WITH POLARIS (KS ₂ )  TUG (BASIC)  VEHICLE LOSSES/REFLIGHTS		232 232 3 (239)
FLEET SIZE REQUIREMENTS	,	
FOR OPERATIONS FOR RELIABILITY		<u>8</u> <u>3</u>
TOTAL	5	
REQUIREMENT AT IOC (MIN)		3
FLIGHTS PER ARTICLE	33.0	30.0

I 29.7

. TURNAROUND CYCLE 32.3 DAYS LAUNCH TO LAUNCH ( CALENDAR DAYS)

FLIGHT SCHEDULE

à,

TUG CONCEPT OPTION 3

LAUNCH SITE ETR/WTR AGENCY NASA/DOD

COMPANY MDAC

	79	8	81	82	83	48	85	98	87	88	86	8	TOTAL
TUG (BASIC) **		т	21	23	36	प्रमु ः	011	177	04	38	17 17	1	370
AUXILIARY STAGE				(2)	(1) (2)	(2)		(3)	(3) (2)				(10)
DROP TANKS													
(отнев)	*												
SHUTTLE	*1	ю	21	23	36	11	140 41	I .	70	38	41 41	41	370

() DENOTES NUMBER EXPENDED.

33 payloads not accommodated due to Shuttle limits of 3 Tug flights in 1980 and 21 in 1981 REMARKS:

Includes reflights due to Tug reliability losses

IVU test flight

FLIGHT SCHEDULE

TUG CONCEPT OPTION 3

LAUNCH SITE ETR AGENCY NASA

COMPANY MDAC

	79	80	81	82	83	ή8	85	98	87	88	89	90	TOTAL
TUG (BASIC)		3	14	12	15	22	22	20	18	15	20	18	179
AUXILIARY STAGE				(2)		(2)		(3) (2)	(2)				6
DROP TANKS													0
(OTHER)	*												Н
SHUTTLE	*	9	17	12	15	22	22	20	18	15	20	18	179

REMARKS: 13 NASA payloads not accomplished due to Shuttle limit on Tug flights () DENOTES NUMBER EXPENDED. * IVU test flight

FLIGHT SCHEDULE

Α,

TUG CONCEPT OPTION 3

LAUNCH SITE ETR AGENCY DOD

COMPANY MDAC

	<del> </del>	<del></del>	<del></del>		
90 TOTAL	129	(1)	0	0	129
	17				17
89	12				12
88	16				16
87	14				77
98	12				12
85	Ħ				11
ή8	17				17
83	13	(1)			13
82	10				10
81	7				7
80		·			
79					
	TUG (BASIC)	AUXILIARY STAGE	DROP TANKS	(отнек)	SHUTTLE

() DENOTES NUMBER EXPENDED.

REMARKS: 20 DOD payloads not accomplished due to Shuttle limit on Tug flights

FLIGHT SCHEDULE

	NASA	
OPTION 3	WTR AGENCY	MDAC
TUG CONCEPT	LAUNCH SITE	COMPANY

<del></del>	<del></del>	7	·		
TOTAL	37	0	. 0	0	37
06	4				ন
89	5			·	5
88	-7				#
87	9				9
98	4				ħ
85	9				9
₹8	<b>4</b>				ক
83	<i>-</i> #				<i>#</i>
82					
81					
80					
79					
	TUG (BASIC)	AUXILIARY STAGE	DROP TANKS	(other)	SHUPTLE

() DENOTES NUMBER EXPENDED.

REMARKS:

FLIGHT SCHEDULE

	DOD	
OPTION 3	AGENCY	MDAC
	WIR	
MCEPT	SITE	<b>.</b>
TUG CONCEPT	LAUNCH SITE	COMPANY

	<del></del>				
TOTAL	22	0	0	0	21
8	Н				н
89	77				77
88	2				a
87	2				Q
98	2				2
85	2				2
78	н				н
83	7				7
82					
81					
8					
79					
	TUG (BASIC)	AUXILIARY STAGE	DROP TANKS	(other)	SHUTTLE

() DENOTES NUMBER EXPENDED.

REMARKS:

FLIGHT REQUIREMENTS

# OPTION 3

	T			Т		1			1							_										
	TOTAL			162	128		8	6		1	308					37	رد	77	58			·····				-
	96		1	)7	17			ı			35				.	4			2		1		-			-
0	60		17	) 7	12		m			1	32					^	-	1	6	<del></del> -	+					-
ää	9		15		16		-	ı		-	33				-	-	8				-					-
87	5		15		14	,	4	2			32				9	,	2	α	+		<del> -</del>			+	-	
98			16		12	_	1	m			7					- -	2	0	1					+		_
85			22	;	17			-	4	25	3	******			9	-	2	80	+			+	<del></del>	+		
84			18		7	Q		7	1	30						-	7	2	-			+		+		
83			7	٥٦	4	ı			-	28					<b>→</b>	-	<b>-</b>	8				+		-		
82		0.	01	70		1	0		-	22				$\parallel$				~ 0	_	-		+	<del></del> .	-	+	
81		יונר		-		1	1		,	21					-			0		-		-			$\frac{1}{1}$	-1
80		8		ı		,	1		-	m			·		_	<u> </u>		0			<del>- 1</del>	_			-	
	ETR	NASA		DOD	NASA	NASA	KICK STAGE	DOD KTCK SMACE		TOTAL			WIR	NASA		DOD	-	TOTAL						-	REFLIGHMS /	S S S S S S S S S S S S S S S S S S S

W.

EQUAL USAGE SCHEDULE

# OPTION 3

	T		· · · · · ·	<del></del>	T	<del>,</del>			· <del></del> -			···				
TOTAL	396	8		88	32	33	33	33	33	33	33	33	33	77	14	
8	04	П									9	9	10	0	6	
89	17	3						2	2	2	5	10	10	5	5	
88	37							4	<b>4</b>	77	2	3	10	10		
87	04						2	_ <del></del>	4	77	10	10	m			
986	1,1	1				5	8	9	9	9	9	17				
85	41					7	9	8	8	8	77					
48	77.71	5		4	ή.	5	η.	6	6	6						
83	36			10	10	10	9									
82	22			7	6	2	₹									
81	21		-	6	8	77										
80	3	,		2	ı											
	NUMBER OF FLIGHTS	NUMBER OF EXPENDED TUCS		TUG ID 1	5	3	17	5	9	7	8	6	10	11	12	LOSSES

#### 2.5 SENSITIVITY STUDY DATA

#### 2.5.1 Two Year IOC Delay

The delay of the IOC two years (Initial to December 1981 and Final to December 1985) impacts the capture analysis in the number of flights, the number of missions accomplished and the fleet size.

The number of flights is reduced by 43 to a total of 323. The years 1980 and 1981, 1984 and 1985 are affected. The number of missions accomplished is significantly impacted. Shown below are the number of missions not accomplished for the years shown.

#### MISSIONS MISSED

		OPTION 3	TWO YEAR IOC DELAY
1980		30	34
1981		2	23
1984		0	25
1985		0	25
	TOTAL	32	109

The fleet size is affected since the initial configuration must operate through 1985 without assistance from the final configuration. Since two tugs are expended in 1984 and three tugs are required in 1985 to perform the deployment missions, the initial tug fleet size must be increased by 1 (see the following chart). The total fleet size, however, remains the same since the total number of expanded tugs is the same. This means the final tug fleet size can be reduced by one. Another changed requirement is the kick stage requirement since the performance of DOD mission 11, within the tug duration capability, requires one kick stage in 1984 and one in 1985.

EQUAL USAGE SCHEDULE OFTION 3 (TWO YEAR IOC DELAY)

800	101AL	S.			23	23	33	35	07	33	33	33	25	18	18	T II		<u>.</u> →
8		}	3		1					-		9	80	-	10			
	-	+	(E)								-	"	-	8		80	-	
SG C	2		- -  -		_				8	2	2	4	ន	9	9	3		
ä	37	5							2	8	80	10	m	4	2			1
87	07		3					2	9	10	10	8	ħ					
86	17		Ē				9	9	7	10	101	5						7
85	33						11	11	11									
84	33	3	(2)	4	-	7	9	10	0									
83	36			5	2 2	2	9	9	<b>.</b>									1
82	22			o		\ \	4											
81																		
80																		
	NUMBER OF	NUMBER OF EXPENDED TICK		TUG ID 1		J	3	7	5	9	7	8	6	10	11	12		ARFLIGHTS / LOSSES



## SPACE TUG SYSTEMS STUDY (CRYOGENIC) SEPTEMBER DATA DUMP

VOLUME 4 Mission Accomplishment
Supplement 3S
Improved Option 3 Performance
SEPTEMBER 1973

PREPARED BY: SPACE TUG STUDY TEAM

L. Q. WESTMORELAND STUDY MANAGER

PREPARED FOR NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
UNDER CONTRACT NO. NAS8-29677

#### PREFACE

This study report for the Tug Program is submitted by the McDonnell Douglas Astronautics Company (MDAC) to the Government in partial response to Contract Number NAS8-29677.

The current results of this study contract are reported in eight volumes:

Volume 1 - Summary, Program Option 1

Volume 2 - Summary, Program Option 2

Volume 3 - Summary, Program Option 3

These three summary volumes present the highlights of the comprehensive data base generated by MDAC for evaluating each of the three program options. Each volume summarizes the applicable option configuration definition, Tug performance and capabilities, orbital and ground operations, programmatic and cost considerations, and sensitivity studies. The material contained in these three volumes is further summarized in the Data Dump Overview Briefing Manual.

This volume contains mission accomplishment analysis for each of the three program options and includes the tug system performance, mission capture, and fleet size analysis.

Volume 5 - Systems (3 Books)

This volume presents the indepth design, analysis, trade study, and sensitivity technical data for each of the configuration options and each of the Tug systems i.e., structures, thermal, avionics, and propulsion. Interface with the Shuttle and Tug payloads for each of the three options is defined.

Volume 6 - Operations (3 Books)

This volume presents the results of orbital and ground operations trades and optimization studies for each option in the form of operations descriptions, time lines, support requirements (GSE, manpower, networks, etc.), and resultant costs.

Volume 7 — Safety (3 Books)

This volume contains safety information and data for the Tug Program. Specific safety design criteria applicable to each option are determined and potential safety hazards common to all options are identified.

Volume 8 - Programmatics and Cost (3 Books)
This volume contains summary material on Tug Program manufacture, facilities,
vehicle test, schedules, cost, project management SR&T, and risk assessment for
each option studied.

These volumes contain the data required for the three options which were selected by the Government for this part of the study and are defined as:

- A. Option 1 is a direct development program (I.O.C.: Dec 1979). It emphasizes low DDT&E cost; the deployment requirement is 3500 pounds into geosynchronous orbit, it does not have retrieval capability, and it is designed for a 36-hour mission. MDAC has also prepared data for an alternative to Option 1 which deviates from certain requirements to achieve the lowest practicable DDT&E cost.
- B. Option 2 is also a direct development program (I.O.C.: 1983). It emphasizes total program cost effectiveness in addition to low DDT&E cost. The deployment requirement is 3500 pounds minimum into geosynchronous orbit and 3500 pounds minimum retrieval from geosynchronous orbit.
- C. Option 3 is a phased development program (I.O.C.: 1979 phased to I.O.C. 1983). It emphasizes minimum initial DDT&E cost and low total program cost. The initial Tug capability will deploy a minimum of

3500 pounds into geosynchronous orbit without retrieval capability, however, through phased development, it will acquire the added capability to retrieve 2200 pounds from geosynchronous orbit. The impact of increasing the retrieval capability to 3500 pounds is also provided.

#### CONTENTS

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## Section 1 PERFORMANCE

#### 1.1 PERFORMANCE GROUND RULES

The payload performance was determined using the classical impulsive velocity equation. The velocities employed were based on the three dimensional finite burning trajectory analyses performed during Task 1. Since most of the missions in the mission model did not exceed three days duration, this figure was used for establishing performance capability even though subsystems are sized for six days. A detailed simulation of the basic geosynchronous deployment mission taking into account the actual losses associated with each engine start and the velocity contributed by propellant settling forces was used to determine an equivalent specific impulse penalty of four seconds which was then used for all missions.

For the geosynchronous transfer, a velocity of 13,972 fps was used which represents the most unfavorable situation (from a performance point of view) of no low orbit phasing being required and the resulting injection to the transfer orbit being performed with only one burn instead of two. This velocity is approximately 80 fps greater than the most favorable two burn transfer injection. For the return, a velocity of 13,920 fps was used.

The following weights and engine data were also employed in the performance computations:

Shuttle Capability	65,000
Ancillary equipment (to install Tug in the Orbiter bay)	2,066
Vented during ascent	269
Tug gross weight at deployment from Orbiter bay	62,665
Tug burnout weight (includes FPR)	6,840
Propellant capacity (@5.5 EMR)	55,500
Engine chilldown and propellant settling (each start)	20
Vented in flight	78
Attitude control propellant Fuel Cell Reactants Engine Ca	95 83. tegory II RL10
Thrust	15,000
I _{sp} (@6.0:1 EMR)	459.2

#### 1.2 GEOSYNCHRONOUS PERFORMANCE

Based on the foregoing ground rules and data, the following geosynchronous orbit performance capabilities were determined at the nominal 5.5:1 EMR:

Deployment 6,840
Retrieval 4,354
Round Trip 2,660

For mission of greater (or less) than three days, the increase (or decrease) in on-orbit consumables must be corrected for using the factors given in Section 1.4.2. Figure 1.2-1 shows how the payload delivery capability decreases as payload is returned.

#### 1.3 PERFORMANCE ENVELOPE

Figures 1.3-1, -2, and -3 present the payload-velocity envelope for the Option 33 Tug starting from 28.5 deg, 55 deg, and 90 deg inclinations, respectively. The significant variation with inclination reflects the Shuttle performance with launch azimuth. For missions below geosynchronous, specific impulse could be increased by off loading LOX only initially to reduce the EMR to 5.0 and gain up to three seconds.

#### 1.4 PERFORMANCE SENSITIVITIES

#### 1.4.1 General Mission Trade Factors

The sensitivity of payload to the two principal performance factors,—Tug inert weight and I_{sp}— are presented as a function of mission velocity in Figure 1.4-1.

#### 1.4.2 Geosynchronous Trade Factors

Specific trade factors for the geosynchronous missions are given in Table 1.4-1. The inert weight factor is applicable to any weight carried throughout the mission, such as structure and residual propellants. The gross weight factor can correct for variations in the Tug gross weight at first ignition such as Shuttle capability, ancillary equipment or propellants vented during ascent.

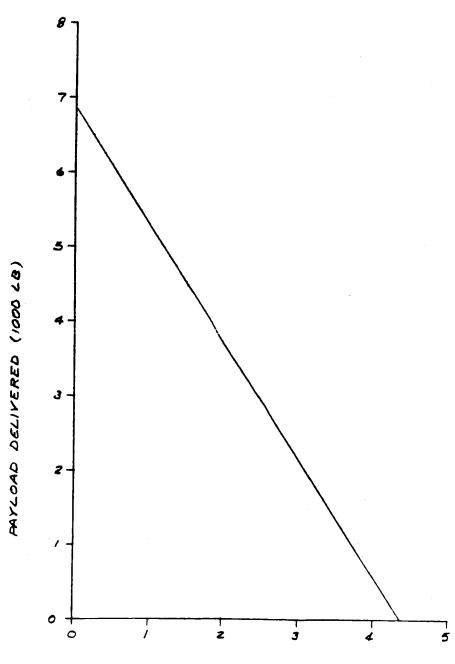
#### 1.5 MISSION PERFORMANCE

The performance capability for each mission in the mission model was computed for each basic mission mode. The missions are defined in Table 1.5-1. Table 1.5-2 is a computer printout of the results and includes the velocities



### GEOSYNCHRONOUS PERFORMANCE CONFIGURATION OPTION 35

*.* 

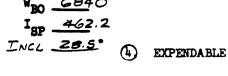


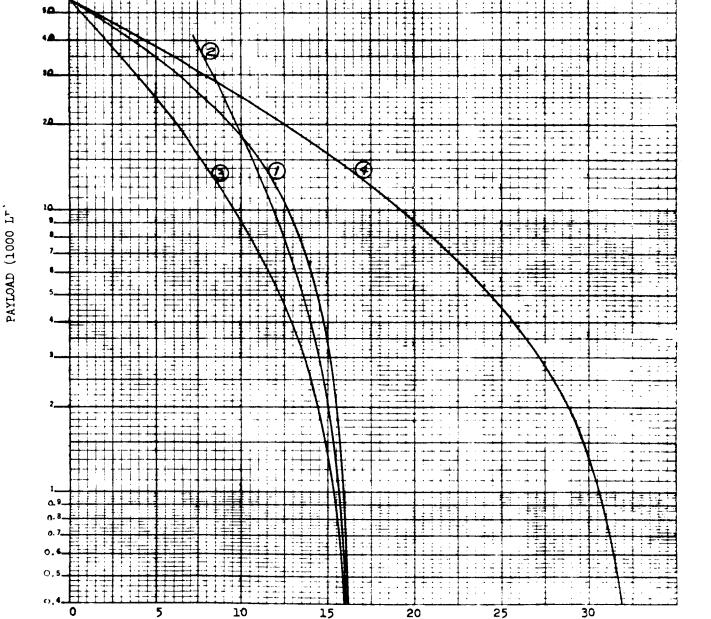
PAYLOAD RETRIEVED (1000 LB)

PREPARED BY, S. P. T.

PAGE NO.

- 1 DEPLOY
- (2) RETRIEVE
- (3) ROUND TRIP





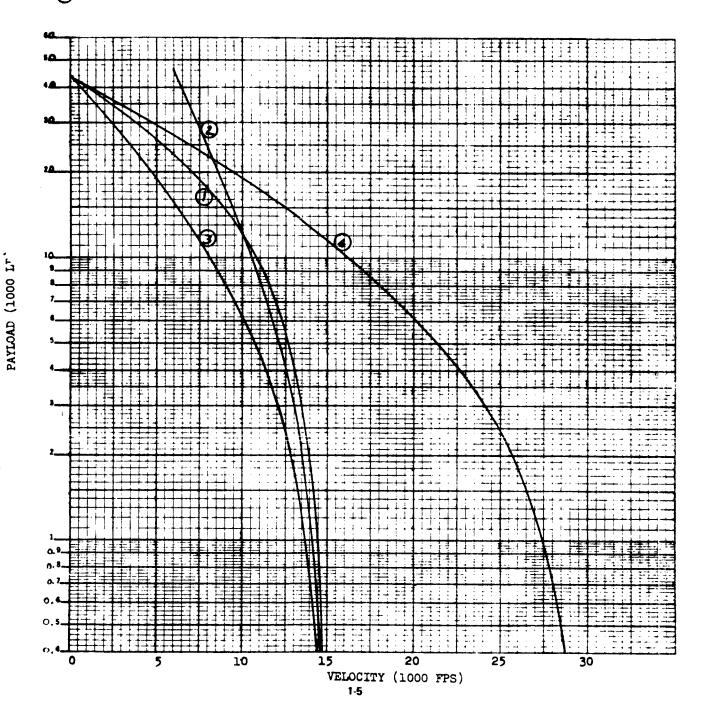
VELOCITY (1000 FPS)

#### PERFORMANCE CAPABILITY

CONFIGURATION OPT 35

(4) EXPENDABLE

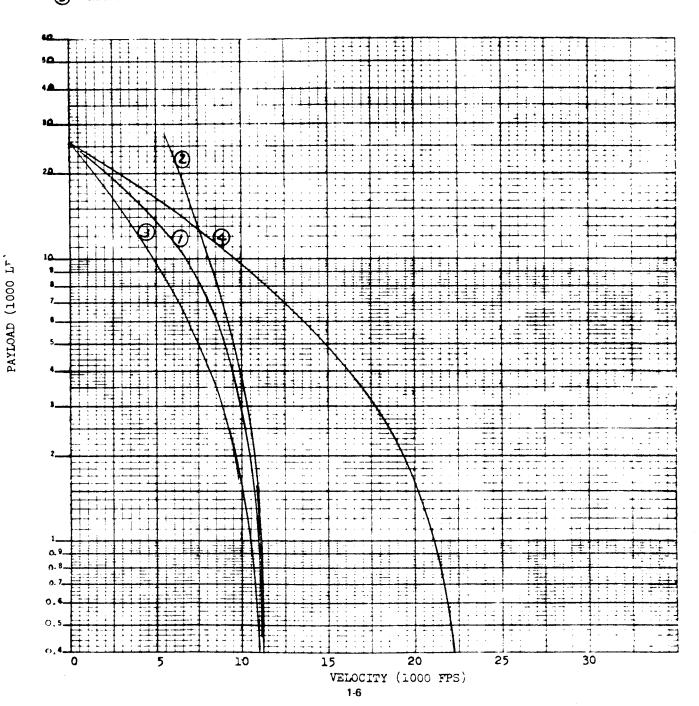
- 1 DEPLOY
- 2 RETRIEVE
- (3) ROUND TRIP



(4) EXPENDABLE

IBP 462.2 INCL 30°

- (1) DEPLOY
- (2) RETRIEVE
- (3) ROUND TRIP





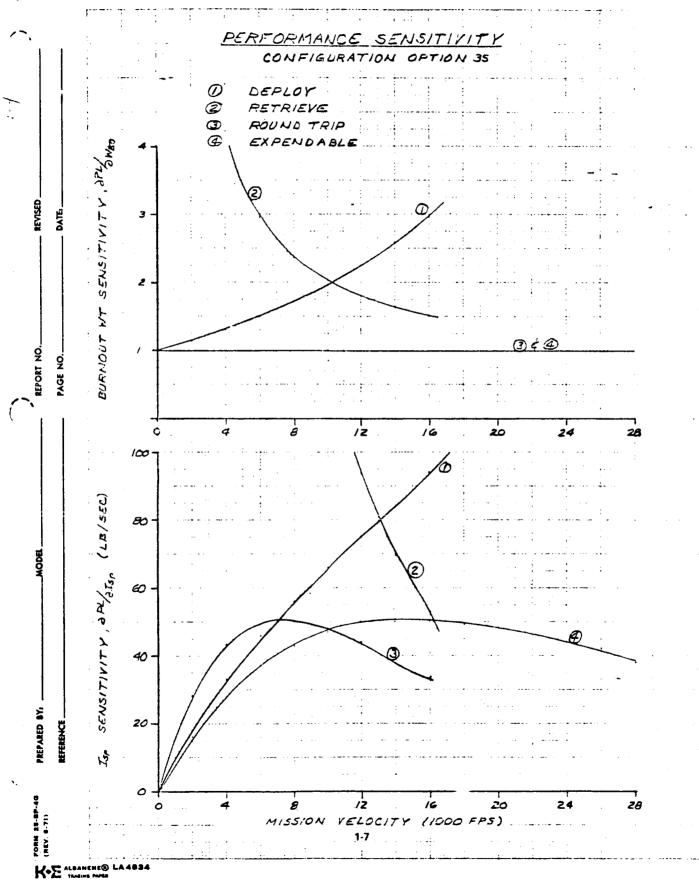


Table 1.4-1
GEOSYNCHRONOUS MISSION TRADE FACTORS

	DEPLOY	RETRIEVE	ROUND TRIP
Burnout Weight: 3PL/2WB0	-2.57	-1.64	-1
Specific Impulse: OPL	84	70	38
Gross Weight: 3 FL 3 Wo	•39	.25	.15
Orbit Losses: PridWoL	-1	64	39

Table 1.5-1
MISSION DESCRIPTIONS

Mission No.	n Hax Hp (nmi)	Incl.	Remarks
1-8	19323	0	Synchronous orbit - single burn transfer orbit injection
1-8A	19323	0	Synchronous orbit - two burn transfer injection
1-8B	19323	. 0	Synchronous orbit - two burn transfer injection with 600 fps for multiple payload deployments
9	lau	Eclip.	
10	6900	55°	-
10A	6900	55°	Alternate - Shuttle launched into 28.5°
11	16Kx30K	20°	
12	180x1800	90°	
13	1Kx20K	90°	
13A	1Kx20K	90 <b>°</b>	ETR Alternate - Shuttle launched into 28.5°
13B	1Kx20K	90°	ETR Alternate - Shuttle launched into 55°
14	300x3000	90°	
15	700	100°	
16	500	99.2°	
17-8	Interplane	tary	ΔV - 13000
19			16500
20			23000
21-2			24000
23			18400
24	•		22000
D11	58K	0,30,60	
D10	860x21K	63.4	Shuttle launch into 63.4° WTR
DlOA	860x21K	63.4	ETR Alternate - Shuttle launched into 55°
D5	750	99°	
D3	13.6кх25к	60°	Shuttle launched into 60° WTR
D3A	13.6x25K	60 <b>°</b>	ETR Alternate - Shuttle launched into 55°
D12	300	104°	
D16	400	98.3°	•

CØNFIGURA	TIØN ØPT 3S	STAGE WT=	6840.00 IS	P=462•20 DEL	ISP=4.00
MISSIØN	GRØSS-WT V-ØUT	PL-RØUND V-BACK	PL-DEPLØY	PL-RETRI EVE	PL-EXPEND
1-8	62665.00 13972.00	2608.05 13920.00	6704.89	4268 • 34	17449.45
1-8A	62665.00 13890.00	2660.75 13920.00	68 40 • 37	4354.59	17584.93
1-8B	62665.00 14190.00	2281 •84 14220 • 00	5986.85	3687.18	17092.91
9	62665•00 14160•00	2220 • 16 14350 • 00	5876•64	3568 • 23	17141.66
10	50665.00 9700.00	6749 • 23 9700 • 00	13032.00	13999 • 58	19399•26
10A	62665.00 12760.00	4257•38 12760•00	10116.85	7350.73	19530.77
11	62665.00 12450.00	4734.06 12450.00	11015•48	8301•93	20091.18
12	32665.00 2285.00	17118 • 16 228 5 • 00	19988 • 11	119221.62	21134-87
13	32665.00 8400.00	3611•15 8400•00	6384•18	8313•75	11636•66
13A	62665.00 13460.00	3251•99 13460•00	8103.52	5431.81	18307.86
13B	50665.00 11200.00	4247.07 11200.00	9078•95	7980•14	16860.77
14	32665.00 3600.00	13203.56 3600.00	16855.63	60939 • 31	18747.55
15	26665.00 1700.00	14332.89 1700.00	16084.77	131597•75	16920.79
16	26665.00 1120.00	16066.18 1120.00	17334•34	219608.87	17874.23
17-8	62665.00 13140.00	3621•42 13250•00	8896•45	6107.61	18859•71
19	62665.00 16740.00	•00 17210•00	• 0 0 1-10	•00	13291.43

20	62665•00 23550•00	•00 24500•00	•00	•00	5843.98
21-2	62665•00 24600•00	•00 25500•00	•00	•00	4971.98
23	62665•00 18720•00	•00 19550•00	•00	•00	10761.29
24	62665•00 22500•00	•00 23500•00	•00	•00	6780.35
D11	62665.00 13930.00	2628.59 13930.00	6762•27	4300.09	17518.75
D10	48 665 • 00 8 500 • 00	8520.52 8500.00	15166•02	19445•12	20500+81
D10A	50665.00 9800.00	6566•13 9800•00	12764.74	13521-58	19221.88
D5	26665.00 1770.00	14132.77 1770.00	15935.67	124918.75	16808.23
<b>D3</b>	48 665 • 00 1 18 50 • 00	2910.54 11850.00	6502-31	5269.06	14943.25
D3A	50665.00 11920.00	3215.31 11920.00	7217.38	5798 • 54	15731.05
D12	26665.00	18076-26	18 699 •8 4	542067.44	18935.80
	500.00	500.00			
D16	26665•00 850•00	16920.80 850.00	17925.08	302013.50	18331.05

derived from Task I. The gross weight reflects the Shuttle delivery capability to the appropriate parking orbit inclinations. In several cases, alternate mission profiles are shown starting from different inclinations. The capabilities with a kick stage were also determined for use in the mission capture analysis but are not shown simply to avoid classifying any data.

## Section 2 CAPTURE ANALYSIS - OPTION 38

#### 2.1 FLIGHT SUMMARY

The data provided in Section 2.1.1 represents a summary of the mission captured by the Option 3S program based upon all constraints of the system potential (Tug capability) and the program schedule (Tug and related support systems availability). Section 2.1.2 identified the missions, from the Option Mission Model, which are not captured by the program and also includes the rationale for their exclusion.

#### 2.1.1 Flight Summary Data

Tables 2-1 through 2-5 present the number of flights per year for each of the flight modes used in Option 3S. Also shown are the total Shuttle and Tug flights and the number of missions identified as requirements in the Option Mission Model. On Table 2-1 the number of missions accomplished is identified.

The mission modes used in this option are defined as follows:

#### Deploy

- Single Payload The deployment of one payload to one location and velocity vector and return of the Tug to the Shuttle.
- Multi 2 Payload The deployment of two payloads to one location and velocity vector and return of the Tug to the Shuttle.
- Multi 3 Payloads The deployment of three payloads to one location and velocity vector and return to the Shuttle.
- Kick Stage Large The deployment of one or more payloads to one location and velocity vector using a Polaris kick stage as a second stage to the Tug. The kick stage is expended and the Tug returns to the Shuttle.
- Expendable The deployment of one payload to one location and velocity vector. The Tug is expended.

#### Retrieval

Single Payload - The retrieval of one payload from one location and return to the Shuttle.

#### Round Trip

- Deploy 1/Retrieve 1 Deploy one payload at one location and velocity vector (maneuver 60° phase angle position for synchronous equatorial mission between deployment and retrieval), retrieve one payload and return to the Shuttle.
- Deploy Multi/Retrieve 1 Deploy one payload at one location and velocity vector, maneuver to a second position and velocity vector and deploy second payload, if three satellites are to be deployed, maneuver to a third position and velocity vector and deploy third satellite and retrieve another satellite at that position (for synchronous equatorial mission each maneuver shall be 60° phase angle).
- Sortie Carry a payload to one orbital location, remain in that orbit for 130 hours (22 hours for initial configuration) and return the payload to the Shuttle.

FLIGHT SUMMARY-WIR-OPTION 3S

•						Calendar		Year					
4	Flight Mode	8	81	82	83	48	85	98	87	88	89	8	Total
	Shuttle	ı	1		8	5	8	6	8	9	6	5	58
Totals	Tug	1	-	1	8	5	8	6	æ	9	0	٦	5.8
	Deploy												
	Single Payload												
·	Multi2 Payloads				9		-				~		
	Multi3 Payloads				7	71		-	-		7 -	-	01
-	Kick-Stage Mode										1	1	
Tug	Expendable							T	-				
Flight   Distribution													
	Retrieve												
	Single Payload					٦		17	-	,		,	-
									-	1		1	#
	Round Trip												
	Deploy 1/Retrieve 1					2	7	7	-	-	~	٥	ارد
	Deploy Multi/Retrieve 1										) -		7
	Sortie				-1		7	-		-			7
	Total						-	1				I	
	Deploy	0	0	0	16	5	11	2	80	4	16	2	72
Mission Model	Retrieve	0	0	0	-	7	7	α	-	4	<u>ا</u> ــــ	-	-
								,		-	-	,	
				1		-		_	_	_	_	_	

FLIGHT SUMMARY-ETR-OPTION 3S

						Calendar	•	Year					
	Flight Mode	80	81	82	83	78	85	98	87	88	89	96	Total
	Shuttle	3	21	22	28	35	25	56	31	27	56	30	274
Totals	Tug	3	21	22	28	25	25	56	31	27	56	30	274
	Deploy	-											
	Single Payload	3	21	18	25	9	3	1	8	3	9	3	26
	Multi2 Payloads			2	2	П		7	7	7	r-1	П	16
	Multi3 Payloads		_			П	7			7	1	П	5
	Kick-Stage Mode			2	7	2		ж	2				10
Tug	Expendable					a		Н			m	П	8
Flight Distribution													
	Retrieve												
	Single Payload					9	1	4	2	77	2	7	23
	Round Trip												
	Deploy 1/Retrieve 1					17	20	16	14	ħΤ	13	20	114
	Deploy Multi/Retrieve 1		•							Н			Т
	Sortie												
	Total												
	Deploy	34	23	77	32	32	56	25	33	30	27	29	315
. Mission Model	Retrieve	0	0	0	0	23	21	20	16	19	15	54	138

FLIGHT SUMMARY-DOD-OPTION 3S

						5							
						care	calendar	Iear					-
	Flight Mode	80	81	82	83	₹8	85	98	87	88	89	8	Total
	Shuttle	ı	L	10	17	18	12	17	17	17	7,7	18	147
Totals	Tug	1	-	10	17	18	12	7.1	17	7.	F	٥	1.1.5
•	Deploy									1	+	OT	T+1
	Single Payload		7	8	10	2	2	-	, «	-	-	C	7.0
	Multi2 Payloads			2	⇒	-	-			1	4	7	0
	Multi3 Payloads				-	2		-	-	7	C	c	5
	Kick-Stage Mode				-			1	1	1	7	2	7 7
Tug	Expendable				<u> </u>				-				
Filght Distribution													
	Retrieve												
	Single Payload					m		m	7	-	-	~	
							-				1		
	Round Trip												
	Deploy 1/Retrieve 1					70	7	12	07	7,7	0		73
	Deploy Multi/Retrieve 1												
	Sortie				 		7			<del> </del>	-	-	17
	Total								1				
M. C. C. M. C. C. C. C. C. C. C. C. C. C. C. C. C.	Deploy	20	7	12	25	20	15	16	17	18	17	19	186
TOTOL HOTOSTI	Retrieve	0	0	0	7	13	80	15	13	15	11	17	8
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FLIGHT SUMMARY—NASA—OPTION 3S

						Calendar		Year					
[E4	Flight Mode	80	81	82	83	₹8	85	98	. 87	88	89	06	Total
	Shuttle	3	14	12	19	22	21	18	22	16	21	17	185
Totals	Tug	3	14	12	19	22	21	18	22	16	21	17	185
	Deploy												
	Single Payload	3	17	10	15	7	7		5	2	5	1	09
	Multi2 Payloads				4			-1	7	4	ℷ	٦	18
	Multi3 Payloads												
	Kick-Stage Mode			α		2		3	2				6
Tug	Expendable					0		7	·.		m	М	æ
Flight Distribution													
3	Retrieve												
	Single Payload					5	٦,	5	7	5	1	3	24
	Round Trip												
	Deploy 1/Retrieve 1					6	18	ω	2	<i>-</i>	7	11	62
	Deploy Multi/Retrieve l		·				7				r-1		7
	Sortie												
	Total												
	Deploy	17	91	12	23	17	22	91	77	16	56	15	201
Mission Model	Retrieve	0	0	0	0	14	20	13	10	10	6	14	90

FLIGHT SUMMARY-OPTION TOTAL-OPTION 3S

	- Forth	100	332	332		0.7	7 %	2 =		γ .α			37	1		25	3 -		<b>.</b>	0.1	90,	267	100
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Calendar	85	33	3	33		~		П					7			25		7~		37	28	65	65
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	83	36	3	36		25	8	п	н	-				-				-	1	148		61	#-
	82	22		22		18	2		Ŋ									-		77.7	0	†Z	77
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	Flight Mode	Shuttle	E	zug.	Deploy	Single Payload	Multi2 Payloads	Multi3 Payloads	Kick-Stage Mode	Expendable		Retrieve	Single Payload		Round Trip	Deploy 1/Retrieve 1	Deploy Multi/Retrieve 1	Sortie	Total	Deploy	Retrieve	Total	Total
·*····	,±4		0 0 0	STROOT					-	Tug Flish	Distribution										Tepow worsstw		Accomplishment

#### 2.1.2 Missions Not Captured

The availability of the Shuttle in 1980 of 3 Tug flights and in 1981 of 21 flights constrains the Tug mission assignments in these years. The following rationale was used to select payloads for each of the Tug flights in those years.

#### 1980

- 1. The first flight would be a simple flight with a light payload (although large enough to warrant use of the STS). NASA Mission 4 was selected.
- 2. The second flight would be a simple flight with a heavy payload. NASA Mission 8 was selected.
- 3. The third flight would be one of the most numerous. NASA Mission 3 was selected.

#### <u> 1981</u>

 Delete missions which could be performed with current expendable launch vehicles. NASA Mission 1 (two payloads) were deleted.

The following missions were not performed in 1980:

NA		DOD	
MISSION	NUMBER OF PAYLOADS	MISSION	NUMBER OF PAYLOADS
1	2	2	2
2 .	l	3b	1 .
3	2	15	1
6	1	3a	14
7	ı	4ъ	1
8	1	8	2
9	1	lla	3
11	ı	11b	3
17	1	llc	3

Two NASA Mission 1 payloads were not performed in 1981.

All other missions, both NASA and DOD, were performed as required.

#### 2.2 ADDITIONAL PAYLOAD CAPTURE

The capability of the Option 3S Tug to capture missions beyond the Option 3S mission model is illustrated in Table 2-6, which indicates the mode in which the Option 3S Tug can capture various missions. The missions identified are those which are contained in the total mission model, but are excluded in the Option 3S mission model.

NASA missions 17 and 18 can be deployed in the normal Tug reusable deployment mode. NASA missions 19, 22, 23, and 24 can be performed by expending the Tug. NASA mission 20 can be accomplished in a Tug reusable mode using a kick stage (Polaris kick stage). NASA missions 6 and 7 can be retrieved in a normal retrieval mode after the orbital energy has been reduced. The reduction of the orbital energy is accomplished by using the excess capability in another mission to bring the payload part way back. The mode is called the "nudge" mode. NASA missions 8 and 10 can be retrieved in the normal retrieval mode.

DOD mission 12b can be performed by the Option 3S Tug in the normal round trip sortie mode.

OPTION 3S ADDITIONAL PAYLOAD CAPTURE POTENTIAL

Mary   DEPLOY RETRIEVE   SORTIE   DEPLOY   RETRIEVE	MISSIO	MISSIONS EXCLUDED FROM		OPTION MISSION MODE	MODE	CANDID	CANDIDATE CONFIGURATION 3S	SS
Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   Number   N	DES	IGNATION	DEPLOY	RETRIEVE	SORTIE		TUG MODE	
5000         -         -         -         -         Nudge 450 fps 10           5500         -         3         -         Normal         7           4000         -         10         -         Normal         2           2000         3         -         -         Normal         2           2000         3         -         -         Normal         2           7900         3         -         -         Expendable         3           1500         4         -         -         Expendable         4           6600         2         -         -         Expendable         4           6600         2         -         -         Expendable         4           6600         2         -         -         Expendable         4           14400         4         -         -         Expendable         4           2400         -         -         -         -         -           2400         -         -         -         -         -           2400         -         -         -         -         -           2400         -		T.M.				DEPLOY	RETRIEVE	SORTIE
5500		5000	1	ı	ı		450 fps	
μ000         -         10         -         Normal         2           2000         3         -         -         Normal         2           2000         3         -         -         Normal         2           7900         2         -         -         Expendable         3           1500         μ         -         -         Expendable         μ           4000         μ         -         -         Expendable         μ           6600         2         -         -         Expendable         μ           6600         2         -         -         Expendable         μ           2400         -         -         -         Expendable         μ           2400         -         -         -         -         -           2400         -         -         -         -         -           2400         -         -         -         -         -           2400         -         -         -         -         -           2400         -         -         -         -         -           25         -         -	- 1	5500	1	ю	1		750 fps	
9500         -         2         -         Normal         2           2000         3         -         -         Normal         2           3300         2         -         -         Kick Stage         4           7900         4         -         -         Kick Stage         4           4000         4         -         -         Expendable         4           4000         5         -         -         Expendable         5           4400         4         -         -         Expendable         4           2400         -         -         -         Expendable         4           2400         -         -         -         Expendable         4           2400         -         -         -         -         -           2400         -         -         -         -         -           2400         -         -         -         -         -           2400         -         -         -         -         -           25         -         -         -         -         -           25         -         -	ı	7,000	•	10	ſ			
2000         3         -         -         Normal         3           3300         2         -         -         -         2           7900         3         -         -         Expendable         3           1500         4         -         -         Kick Stage         4           4000         4         -         -         Expendable         4           6600         2         -         -         Expendable         4           4400         4         -         -         Expendable         4           2400         -         -         -         Expendable         4           2400         -         -         -         -         -           2400         -         -         -         -         -           2400         -         -         -         -         -           2400         -         -         -         -         -           2400         -         -         -         -         -           250         -         -         -         -         -           250         -         -         -<		9500	1	2	ı			
3300   2   -	71 N	2000	3	ı	1			
7900         3         -         -         Expendable 1         1           1500         μ         -         -         Expendable μ           μμοο         μ         -         -         Expendable μ           μμοο         μ         -         -         Expendable μ           2μοο         -         -         Expendable μ           2μοο         -         -         -         -           2μοο         -         -         -         -           DFPLOY         22         -         -         -           SORTIE         -         -         -         -           ποση         -         -         -         -           ποση         -         -         -         -           -         -         -         -         -           -         -         -         -         -           -         -         -         -         -           -         -         -         -         -           -         -         -         -         -           -         -         -         -         -	N 18	3300	2	•	9			
1500         μ         -         -         Kick Stage         μ           4000         μ         -         -         Expendable         μ           6600         2         -         -         Expendable         μ           1μ00         μ         -         -         Expendable         μ           2μ00         -         -         -         -         -           2μ00         -         -         -         -         -           DFPLOY         22         -         -         -         -           SORTIE         -         -         5         -         -           TOTALI         -         -         -         -         -	N 19	7900	m		1			
μοσο         μ         -         -         Expendable         μ           6600         2         -         -         Expendable         μ           μμοο         μ         -         -         Expendable         μ           2400         -         -         5         -         .           2400         -         -         5         .         .           DRPLOY         22         -         -         22         .           DRPLOY         22         -         -         22         .           SORTIE         -         5         .         .         .           TOTAL         -         5         .         .         .	N 20	1500	7	ı	ı			
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2400       -       -       5 </td <td></td> <td>0044</td> <td>ή.</td> <td>•</td> <td>ı</td> <td></td> <td></td> <td></td>		0044	ή.	•	ı			
DFPLOY         22         _         _         22           RETRIEVE         _         _         _         _         _           SORTIE         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _         _	1	2400	ı	ı	5		•	Normal 5
DFPLOY         22         _         _         22           RETRIEVE         _         22         _           SORTIE         _         5         _								
DFPLOY         22         22           RETRIEVE         22         22           SORTIE         5         100								
DRPLOY         22								
DEPLOY         22         -         -         22           RETRIEVE         -         22         -           SORTIE         -         5         -								
RETRIEVE         -         22         -           SORTIE         -         5           TOTAL         Lo		DEPLOY	22	9	1	22		
SORTIE - 5 TOTAL LO	TOTAT.	RETRIEVE	1	22			22	
07		SORTIE	•	ı	5			5
£t		TOTAL		617			617	

N = NASA D = DOD

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#### 2.3 FLIGHT DATA

#### 2.3.1 Flight-by-Flight Mission Assignments

The following table (Tables 2-6) present the flight by flight mission assignments for each of the Tug flights for each year of the program. ETR and WTR launches are shown on separate pages.

Each chart shows the following data:

- Flight Number numbering of flights which is arbitrary and has no relation flight sequence or schedule.
- Orbit Mission orbit defined by altitude and inclination. In the case of interplanetary missions the mission velocity is given.
- Flight Mode the flight mode the Tug will operate to perform the mission. Flight modes used by the Option 1 Tug are defined as follows:
  - A single payload deployment
  - A( ) multi-payload deployment
  - A-KL payload deployment using kick stage (planetary mission)
  - A-E payload deployment expending the Tug (planetary mission)
  - AB Round-trip (single payload deployment and single payload retrieval)
  - A()B Round-trip (multi-payload deployment and single payload retrieval)
  - BA Sortie mission (round-trip of one payload with mission duration equal to Tug duration capability)
  - I Mission performed with initial configuration (all missions not so designated are performed with final configuration).

	4 SITE	E	TR	Y	FAR:	1980
FLIGHT	OEBIT	FLIGHT	PAYLUADS		PAYLOAD	
NO.	DEBIT	MODE	UP ·	WEIGHT	DOWN	WEIGHT
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NA.	SA F SYNC.EQ	LIGHT	<u>}</u>			ļ <u>.</u>
	SYNC, EQ	A	4 8 3	1800		
2	"	A	8	3500		_
2 3	11	A	3	2100	_	_
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=UGIIT	08817		PAYLUADS	MEIGHT	PAYLOND	WEIGHT
<i>∾</i> 0.	1005//	MODE	UP	MEIGHT	DOWN	WEIGH
NI	SA) F	1-1647	5			
	SYNC. EQ	()	8	3500		
7		A	7	3000		_
3	"		4	1800		-
4	11	_/1	3	2100	-	_
		A	3	2100		-
6	"	Ω	3	2100		-
7	''	_ /3	3	2100	-	-
£;	11	_//	3	2100		_
9	11	n	3	2100		
10	"	0	3	2100		
11	,,	A	3 2.	1700	-	
12.	/-	A	7.	1700		
13	610: 155	B	10	6.220	_	
14	PORKILK/29	17	11	1700		
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	P	A	2.	690		
2	<del> </del>		2	670		
2 3		A	40	3480		
4	<u> </u>	13	40	3450		
4		19	10	2745		
6	† <del>-</del>	A	B	72430		
7		B	8	2430	<del> </del>	<u> </u>
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LAUNCH	SITE	ET	R	Y	EAR:	1982
FUGHT NO.		FLIGHT	PAYLUADS		PAYLOAD	
<b>₩</b> 0.	OEBIT	MODE	UP	WEIGHT	DOWN	WEIGHT
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NA:	SYNC. EQ	LIGHTS	0	3500	-	
	BAC: 1=Q	19	8	3000		-
2 3	···	A		<del></del>		ļ
3		A	7	3000		ļ
4	1,	A	6	2600		
		A	3	2100	-	
6	1,	A	3	2100		
7			3	2100		
8		A		900		
9		B		900	-	-
10	I AU.	A	9	1400		
//	23,000 fps	A.KL	20	900		_
12		A-KL	20	900		
Do	DF	LIGHTS	5			
,		A	2	690	_	
3 4 5		A	2	690	-	
3		A	36	1570	_	_
4		A	15	1970		
5		A(2)	3a,3a	3140		<del></del>
6		A(1)	3a 3a	3/40		
6		A	3a,3a 4b	3480		
		A	4 b	3480		<del> </del>
8 9		A	8	2430		<del> </del>
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#### MISSION CAPTURE OPTION 35

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70.	<del> </del>	MODE	U P		DOWN	
	CO -					
NA	SA F SYNC, EQ	L164T	5			
		A	8	3500		
3	-	A	8	3500		-
	· · · · · · · · · · · · · · · · · · ·	A	フ	3000	-	-
4	,,	A	7	3000	_	-
<u> </u>	"	A	5 5 5	1800	_	-
6	.,	A	5	1800	_	-
7	"	A		1800	_	-
8	"	A	4	1800	_	_
9	**	A	<i>4</i> 3	1800	_	_
10	4	A	3	2100	-	-
		A	3	2100		_
12	1/	Α	3 3 2	2100	_	_
/3	4	A	2	1700	_	_
14			1	900	_	_
15	30 K x 16 K/29	A	11	1700		_
D	OD F	LIGHTS				
1		A	Z	690	_	_
2		A	2	690	_	_
3		A	36	1570	-	-
4		A	15	1970	_	-
5		A	17	2200	_	_
4 5 6 7		A	17	2200		_
7		A(2)	34,32	3140	_	
8		A(2) A(2)	34,34	3140	<del>-</del> .	
9		A	46	3480	_	
10		A	10	2745		-
11		A	8	2430		-
		A	ø	2430		<del>-</del>
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DOD   FLIGHT   TAYLOADS   WEIGHT   NO.   OLBIT   MODE   UP   WEIGHT     NASA   FLIGHTS   12,13   3000     2	-	WEIGHT
NASA FLIGHTS  / VAROUS A(2) 12,13 3000  Z VARIOUS A(2) 14,15 2800  3 500/99 A(2) 16,16 9000  4 " A(2) 16,16 9000  DOD FLIGHTS  I A(3) 5,5,5 2205  Z A(2) 16,16 5220  3 A(2) 16,16 5220		
VAROUS   A(2)   12,13   3000     2		
VAROUS   A(2)   12,13   3000     2		
2 VARIOUS A(2) 19,15 2800 3 500/99 A(2) 16,16 9000 4 " A(2) 16,16 9000  DOD FLIGHTS 1 A(3) 5,5,5 2205 2 A(2) 16,16 5220 3 A(2) 16,16 5220		- - - - - - - - -
DOD FLIGHTS  1 A(3) 5,5,5 2205  2 A(2) 16,16 5220  3 A(2) 16,16 5220		- - - - - - - -
DOD FLIGHTS  1 A(3) 5,5,5 2205  2 A(2) 16,16 5220  3 A(2) 16,16 5220		- - - - - - -
DOD FLIGHTS  1 A(3) 5,5,5 2205  2 A(2) 16,16 5220  3 A(2) 16,16 5220		6000
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	129	- - - 6000
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	129	6000
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	129	6000
2 A(2) 16,16 5220 3 A(2) 16,16 5220	129	6000
3 A(2) 16,16 5220 4 BA 12a 6000	129	6000
3 A(L) 16,16 \$220 4 BA 12a 6000	124	6000
4 BA 12a 6000	124	6000
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FILLET	T	WTI	PAYLUADS	Y.	PAYLOAD DOWN	1484
NO.	OLBIT			WEIGHT	PAYLOAD	WEIGHT
<i>~</i> 0.		MODE	UP		DOWN	VEIGH
N/	95A A	LIGHT	<u> </u>			
	20 K x 1 k / 90	B	<del>  _ =</del>		12	2000
	300x3K 90		<del>-</del>		/3	1000
2 3 4	700	AB AB	14	800	14	800
	700/100	775	15	2000	15	2000
				<del> </del>		
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			<del>                                     </del>			<u> </u>
D	D F	LIGHTS I-A(3)				
		I-A(3)	5, 5, 5	2205	-	_
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		ETY		Y	EAR:	1984
CIGHT	088,7	FLIGHT	PAYLOADS	WEIGHT	PAYLOAD	
NO.	000	MODE	ΠÞ	WEIGHT	DOWN	WEIGHT
						<u> </u>
NA	50 1	115510N			<del></del>	<del> </del>
				3,00		000
	SYNC. EQ	<i>AB</i>	8	3500		900
	<del></del>	A 8	8	3500		900
3	*/	AB	7	3000		1700
<u>4</u> 5	"	AB	4	1800	2	1700
	,,	AB	3	2/00	2	1700
6	"	AB	1	900	4	1800
7	"	AB	/	900	4	1800
8	"	$\mathcal B$	-	_	3 3	2100
9	••	В	_	_	3	2100
10	,,	B	_	-	3	2100
11	22000 495	I-A-E	24	3300		
12	1 ,,	I-A-E	24	3300	_	
13	I AU.	I-A	9	1400		
	6900 /55				<del> </del>	
14	<del></del>	I-A	10	6000	<u> </u>	+
15	13000 fps	I-A	18	2000	ļ <u>-</u>	<del></del>
16	13000 fgs	I-A	18	2000	<u> </u>	<del>                                     </del>
_17		I-A-KL	20	900		
18	23000 to 5	I-A-KL	20	900		
DO	DM	18810N AB	S 2	690	2	690
2	<del>                                     </del>	AB	2	690	2	690
3	<del> </del>	AB	36	1570	3 6	1570
<u> </u>	<del>                                     </del>	AB	15	1970	15	1970
<del>4</del> 5	-	A(2)	17.17	4400		
<del>}</del>	+			<del></del>		-
6_	<del> </del>	I-A	40	3480	<del>-</del>	+
7	<del> </del>	I-A	44	3480	-	3480
8		B	<del> </del>	<del>                                     </del>	49	· <del>•</del>
9	-	<u>B</u>	7	-		3480
10	<del></del>	AB	3a	1570	34	1570
	<del>- </del>	AB	34	1570	34	1570
/2	-	AB	34	1570	34	1570
13		AB	3a	1570	3a	1570
	1	B	-	_	10	2745
14	<del></del>				· /-	
15		AB	3	2430	8	2430
15		AB	8	2430	8	2430
15		<del></del>	8			
15		AB	8 113,118,115	2430	8	
15		AB	8	2430	8	
15		AB	8	2430	8	
15		AB	8	2430	8	
15		AB	8	2430	8	
15		AB	8	2430	8	
15		AB	8	2430	8	
15		AB	8	2430	8	

		ETR		Y	FAR.	1935
FUGHT	OFBIT	FLIGHT	PAYLUADS		PAYLOAD	
<b>₩</b> 0.	0.2577	MODE	UP	WEIGHT	DOWN	WEIGH'
					<del> </del>	<del> </del>
NA.	KA F	LIGHTS		<del> </del>	<del> </del>	<del> </del>
/	SYNC. EQ	I-A	В	3500	<del> </del>	<del> </del>
2	1,	AB	8	3500	<del> </del>	<del> </del>
3 4 5	14	AB			1	900
4	4	AB	7	3000	2	1700
5	11	AB	<del>                                     </del>	3000	4	1800
6	-,,	AB	6	2600	3 3 3 3	2100
7	•,	AB	4	1800	3	2100
8	11	AB	3	2100	3	2100
9	H	AB	3 3 3	2100	3	2100
10	,,	AB	2	2100	3	2100
11	4	AB	<del>                                     </del>	2100	3	2100
/2	"			2100	3	2100
/3		AB		1700	3 3 5 5	2800
14	,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,,	AB	<del></del>	900	5	2800
15	30 x 16x /29	8		_		2800
/3	129	AB	11	1700	11	1700
						· · · · · · · · · · · · · · · · · · ·
Do	D FL	IEHTS				
/		AB	2	690	2	690
2		AB	2	690	2.	690
3 4		AB	15	1970	15	1970
4		I-A	6	3480		
5		I-A	6	3480	_	
6		AB	46	3480	46	3480
7		AB	46	3480	46	3480
8		AB	8	2430	3	2430
9		AB	8	2430	В	2430
10			11 e 11 c 11 c	2550		
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AUNCI	1 SITE	WT		Υ.	EAR!	1985
FUGHT	ORBIT	FLIGHT	TRAYLUADS UP	WEIGHT	PAYLOAD	WEIGHT
NO.		MODE			SOWN	ļ
		<u> </u>				
	52	LIGHT	12 12 11	3800	14	800
	VARIOUS	19(3) 2	12,13,14	2000	15	2000
	500/13	48	15	4500	16	4500
3			16	4500	16	4500
<u></u>	11	AB AB	16	4500	16	4500
	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	.03	160	4500	16	4500
<u>lo</u>	**		7.00			1
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72	DD F	IGHTS		<del> </del> -	<del> </del>	-
<u>\$7</u> 1		A(2)	16,14.	52.20	_	_
2	<del></del>	BA	12a	6000	12a	6000
					<del></del>	
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#### MISSION CAPTURE OPTION 35

FLIGHT		FLIGHT	PAYLOADS		PAYLOAD	
NO.	ORBIT	MODE	UP	WEIGHT		WEIGH
		1100=		ļ	DOWN	
1/0	SA F	<del></del>		<u> </u>		
	SYNC, E	LIGHTS				
- '	WINC. E		8	3500	)	900
2 3	-	AB	8 3 3	3500		900
- <del></del>	"	AB	3	2100	2	1700
4 5	,,	AB	3	2100	<u>2</u> 4	1700
6	,	48	3	2100	4	1800
7		AB	1	900	3	2100
	"	<u>B</u>		_	3	2100
<u>3</u>		8			3	2100
10	1 A.U.	I-A(2)	9,9	2800		_
	729	В			Ц	1700
_//_	16500 fps		19	5500	_	
12	24000 fps	I-A-E	22	2500	_	
/3	18406 45	I-A-KL	23	5000	_	
14	18400 fps	I-A-KL	23	5000	_	
Da	DF	LIGHTS				
		198		690	2	690
_ 2		AB	2	690	2	690
3		AB	36	1570	36	1570
4		I-9	17	2220		_
		AB	39	1570	3a	1570
6		AB	34	1570	34	1570
		AB	34	1570	34	1570
8		AB	3a	1570	34	1570
9		AB	46	3480	46	3480
10		8	_		10	2745
		AB	В	2430	8	2430
12		AB	8	2430	8	2430
						2770
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		(4)		,Y	EAR:	1986
FUGHT	08317	i .	TAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGH
<del>~~.</del>		MODE	UP		DOWN	
NA	5,0 F	LIGHT 8 B AB	<u>.</u>			
/	10 160/65	8	_	-	12	2000
<b>2</b> 3	JOKKIK/GO	В		-	13	1000
3	310×3000/0.	1913	14	800	14	800
4_	177/10	193	15	2000	15	2000
,D	)))	1647				
/	<b></b>	I-12(1)	555	2205		
	<del> </del>	138	16	2610	16	2610
3	<u> </u>	AB	16	2610	16	2610
4	<del> </del>	В			16	2610
<u> </u>	<b></b>	3			16	2610
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FUGNT	ORBIT		PAYLUADS		PAYLOAD	
<b>~</b> 0.	-	MODE	UP	WEIGHT	DOWN	WEIGHT
NAS		LIGHTS				<del> </del>
	SYNC, EQ	I-A	8	3500		<del> </del> -
2 3	H	AB	8	3500	1	900
3_	16	I- A	7	3000		
4 5	4	I-A	7	3000	<del>-</del>	
5	"	A(2)	6,3	4700		-
67	"	AB	4	1800	3	2100
	11	AB	4	1800	3 3 3	2100
8	*	AB	3 3,3 3,3	2100	3	2100
	• • • • • • • • • • • • • • • • • • • •	A(2)	3.3	4200	_	
10	••	A(2)	3.3	4200	_	
	1,	A(2)	1,2	2600		_
15	6900 /55	A	10	6000	-	_
13	FOR A ILK 29	A	11	1700	_	_
14	16,500 fps		19	5500	_	-
15	1,	I-A-KL	19	5500	_	_
16	24000 fps	I- A-E	22	2500	_	
Do	D F	LIGHTS				
	~	AB	2	690	2	690
2		AB		690	2	690
3		AB	3 6	1570	36	1570
4		AB	15	1970	15	1970
5		A	6	3480		
67		A	4a	3480		
		A B B	44	3480		
8		3			44	3480
9					49	3480
10		AB	<u>3</u> a	1570	34	1570
11		AB	34	1570	34	1570
		78	34	1570	34	1570
15		AB	34	1570	34	1570
13 14 15		AB	<u>B</u>	2430	8	2430
- '2		AB	8	2430	В	2430
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1111114	1 3/12	WT		Y.	EAR.	1987
FUGHT	OLBIT	FLIGHT	ı	WEIGHT	PAYLOMO	WEIGHT
<b>₩</b> 0.		MODE	UP	ļ	DOWN	
44.0				ļ		
	1/1/11/11/15	L16117	12 12 111	2000	14	300
	700 /30	A(3) B AB	15	2000	15	2000
3	500/99	B		-	16	4500
<u> </u>	11	В			16	4500
4 5	13	Ŕ	<u> </u>		16	4500
6	41	5		•	16	4500
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Tre	<u> </u>	10117-5		+	<del> </del>	<del> </del>
ر المساد	D FL		5,5,5	2205		
/ Z		BA 3)	124	6000	12a	6000
			120			<u> </u>
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FUGHT		FLIGHT	Troil NAT -		EAR:	1988
NO.	DEBIT		PAYLOADS	WEIGHT	PAYLOAD	WEIGHT
70.		MODE	WP	•	DOWN	WEIGH
NA	SA F	LIGHTS				
	SYNC, EQ	A	В	3500		
	//	AB	8	3500	1	900
3	"/	AB	7	3000	4	1800
4 5	41	A(2)	4.3	3900		,,,,,
	И	A(2)	3 3	4200		<del> </del>
6	"	A(2)	3,3	4200		<del> </del>
7	11	A(2)	3,3	4200		
8	11	A(2)B	177	1800	3	2100
9	4	В	<del>                                     </del>	7000	4	
10	1,	8 8	<b>†</b>			1800
11	IAU	A	9	1400		1700
12	30 Kx 16k/29	ß	7	1700		
	7.21		<del>                                     </del>			1700
			<b></b>			
Do	D F	-IGHTS				
/		AB	2	690	2	690
2_		AB	2		2	690
3		48		690		
2 3 4 5	<del></del>	A8	36	1570	36	1570
- 3		A	15 17	1970	15	1970
6		AB		1570		
7		_ AB	3a 3a		34	1570
	- <del>-</del>	190		1570	34	1570
8		AB AB	34	1570	34	1570
			3a	1570	34	1570
10		AB	46	3480	46	3480
		AB B	43	3480	46	3480
/2		<u> </u>			10	2745
/3		AB	8	2430	8	2430
14		AB A(3)	8 11a, 11a, 11a	2430	8	2430
15		A(3)	119,119,119	2550		
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		WTI		Υ.	1938		
FUGHT NO.	OLBIT	MODE	PAYLOADS UP	WEIGHT	PAYLOAD DOWN	WEIGHT	
MA	5,4) 7.	B B B AB AB					
	1800× 180//	B	<u> </u>	_	/2	2000	
. 2	20KX1K/110	В		_	13	1000	
3	300×3000/5	AB	14	800	13	800	
4	700/100	AB	15	2000	15	2000	
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Do	D FL						
/		48	16	2610	16	2610	
7_		AB	16	2610	16	2610	
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FUGHT	H SITE			Y	FAR:	1989	
NO	OCBIT	FLIGHT	PAYLUADS	WEIGHT	PAYLOAD		
	<del> </del>	MODE	UP	W 1 10 (4)	DOWN	WEIGH	
4/0	<del> </del>	<del> </del>					
NA	A F	IGHTS					
2	SYNC. FR		8	3500	-	_	
<del>2</del>	<del> </del>	AB	8	3500	/	900	
3 4 5	1.1	AB	7	3000	4	1800	
<del></del>	"	19(2)	5,5	5600			
<del></del>	-'-	A	5	2800			
67	''	AB AB	3	2100	3	2100	
	"	AB	3	2100	3	2100	
8	**	L 17B		900	3	2100	
	1/	AB B A	2	1700	3 3	2100	
/0	30K × 16K/29	B			3	2100	
	/19	14	11	1700		_	
/2	13000 fps	A		1000		_	
	24000 (10	A	/7 22	1000		_	
14	24000 fps	A-E		2500	_		
15	22000 frs	A-E	24	3300	_	-	
16	11	A-E	24	3300	_		
		······································					
	20D #	-LIGH	5				
		48 48	2.	690	2	690	
2		AB	2	690		690	
3		A8	15	1970	2 15	1970	
4 5 6 7		48	17	2220	17	2220	
_ <del>```</del> _		В		-	17	2220	
9		A .	6	3480	_	-	
		AB	46	3480	46	3480	
8		A8 A8	8	2430	8	2430	
9		48	8	2430	8	2430	
10		A(3)	110,110	2550	_		
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FLIGHT	08817	FLIGHT	PAYLUADS		PAYLOAD		
~0	005//	MODE	UP	MEIGHT	DOWN	WEIGHT	
NA:	SA FL	IGHTS					
	SYNC. EQ	AB	8	3500	1	900	
2 3	"	AB	8	3500	1	900	
3	*/	AB	6	2600	3	2100	
4 5	"	AB	6	2600	3 3 3 3	2100	
	11	AB	3 3 3	2100	3	2100	
<b>6</b> 7	"	AB	3	2100	3	2100	
	"	AB	3	2100	3	2100	
<u>8</u> 9	//	AB		900	4	1800	
	41	AB		900	2	1700	
10	1 Au	A(2)	9,9	2800			
	6900 /55	A	10	6000		-	
/2	30K x 16K/29	В			11	1700	
13	24000 fps	A-E	22	2500	-	_	
`							
			ļ	<u> </u>	<u> </u>		
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Do	D FL	IGHTS	ļ	1		1	
2		AB	2	690	2	690	
	ļ	A 8	2	690	2	690	
3	<del> </del>	198	36	1570	36	1570	
4	<b>+</b>	AB	15	1970	15	1970	
	<del> </del>	AB	/7	2226	17	2220	
7	<del> </del>	B		7//0	17	2750	
3	<u> </u>	A	49	3480		<del>-</del>	
9	<del> </del>	B	<u>4a</u>	3480	44	3480	
10		B	<u> </u>		44	3480	
11	<del> </del>	AB	34	152-		1520	
/2		AB	34	1570	3a 3a	1570	
13	<u> </u>	AB	34	1570	3a	1570	
14	<del>                                     </del>	AB	39	1570	34	1570	
15	<del>                                     </del>		8	2430	8		
15	<del>                                     </del>	AB AB	8	2430	8	2430	
17	<del>                                     </del>	A(3)	1/2,1/2,1/2			2/50	
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FUGAT	T	FUGHT	PAYLOADS	1	PAYLOAD	1989		
<i>~</i>	OCEIT	17705 UP		WEIGHT	DOWN	WEIGHT		
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2	700/100	AR	12,13,14	2000	14	2000		
3	500/99	A(2)		9000	15			
3	11	17(2)	16,16	9000		<del></del>		
5	11	19(2)	16,16	7000				
			//					
				ļ				
	20 F	16HTS						
2		A (3)		2205				
<del></del>		43	16	2610	16	7.610		
3		<u>93</u>	16	6000	16	2610		
		BA	12a	6000	120	6000		
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NO.	OCBIT	FLIGHT	UP	WEIGHT	PAYLOAD DOWN	WEIGHT
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	201.412	B B			13	1000
3	300 × 3 % /2	71.6	14	800	14	800
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	7/53			2000	13	12000
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		161175	5, 5, 5	2205		
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#### 2.3.2 Mission Model

The mission model for Option 35 is provided in the following table (Table 2-7). This is the mission model provided by the Government and is repeated here for completeness. The data shown on the table includes:

- 1. Mission Number (and DOD identification number for DOD missions)
- 2. Payload Weight (in pounds)
- 3. Payload Length and Diameter (in feet)
- 4. Number of mission per year (1980 through 1990) for both up payload and down payload traffic.
- 5. Total traffic for each payload
- 6. Subtotal yearly traffic for NASA and DOD
- 7. Total yearly traffic

MICS	1001	MODEL
141123	16710	1000-

#### OPTION 35

	7
1	
	Y

	NEIGHT L D	80	81	82	83	84	ଞ୍ଜ	86	87	88	89	90	TOTALS
1	900	2	2/	2/	1/	2/2	1/1	1/2	-/-	2/1	1/	2/2	17/10
2	1700 8 B	1	2/		1/	/3	1/1	/2	1	/1	1/	/	7/8
3	2100	3	7/	3/	3/	1/3	5/7	5/3	6/3	7/1	2/5	3/5	45/27
4	1800	1/	1/		2/	1/z	1/,	/	2/	1/2	/	/	9/8
5	1800				3/		/3				3/		6/3
6	2600 12 8	1/		1/			1/		1/			2/	60
7	3000	1	1/	2/	2/	1/	2/		2/	/	//		13/0
8	3500	2/	1/	1/	2/	2/	2/	2/	2/	2/	2/	2/	20/0
9	1400	1/		1/		//		Z		1/		2/	80
10	6000	/	1/	/		1/			1/			/	40
11	1700	1/	1/		1/		1/1	/	1/	/	//	1	64
12	2000				1/	/1	1	1	1/	/,	1/	1	44
/3	1000				1/	/	1/	1	1/	1	1/	1	44
14	800	/			1	1/	1/	1/	1/	1/	1/	1/1	87
15	2000	-			1	1/	1/	1/	1'/	//	1/	1	8 7
16	4500				4/		4/4		4		6/		14/8

	^	115	\$ 10	אכ	MO	DE	۷	OF	アノ	ON	35(	CON	r.)	1	
		NE	GHT	80	81	82	83	84	85	86	87	88	89	90	TOTALS
17	,	12	10	1	1/								2	/	3
18		12	10	/				2				/			2
19		20	12			./				1/	2/	/	1	/	3
20			10			Z		2/		/	/	/	1/	1/	4
21			10										1	/	0
22			12							1	1/		1/	1	4
23		50 17	12						/	2/			/	/	2
24			12					2					2/	/	4
													/	/	
												$\overline{/}$			
												/			
SUB- TOTAL	NASA		/	40	16/0	12/0	23/	17/4	22/20	16/13	24/10	16/10	26/9	15/14	201

MISSION MODEL OPTION35 (CONT.)

+	1
	Y

		NEIGHT	80	81	82	83	84	85	86	87	88	<i>8</i> 9	90	TOTALS
		690	2/	2/	2/	2/	2/	z	2/	2/	2/	2/	2/	22/
25	2	12 5		$\angle$	<u> </u>		/2	/2	/2	/z	/2	/2	/2	14
26	36	1570 15 5	1/		/	1	1/		/,	/	/,		/	8/5
27	15	1970	1/		/	'/	-	/-		1/1	/_	//	//	96
28	17	12 10				2/	2/		//		/	1/2	1/2	8/4
29	126	2400												0/0
30	6	3480 20 9						2		1		//		4/0
31	4a	3480		2/			2/2			2/2			2/2	3/6
3Z	3a	1570	4		4	4/	4/4		4/4	4/4	4/4		4/4	32/20
33	46	3480 25 15	1/		2/	1/		2/2	1/		2/2	1/		10/6
34	10	2745		1/		1/	/		/,		/,			2/3
35	8	2430	2/	2/	2/	2/	2/2	2/2	2/2	2/2	2/2	2/2	2/2	22/4
36	11a	850	3/			3/					3/			9/0
37	116	96	3				3					3		90
38	11 c	96	3/					3/					3	9/0
39	5	735				3/	3/		3/	3/		3/	3	18/
40	16	2610 14.5 6.7				4/		2/	2/4		2/2	2/2		12/8
41	12a	20 10				1/		1/		1/		1/1		44
SUB.	DOD		20/	76	12/0	25/	20/	15/8	16/15	17/	18/ 15	17/	19/14	
TOTAL			34/	23/0	24/	48/	37/27	37/ 28	32/ 28	41/ 23	34/ 25	43/20	34 28	387/

#### 2.4 PROGRAMMATICS INPUT DATA

The following data was provided as a basic input to the programmatics studies. The first chart summarizes the total flights and hardware requirements. The second group of tables show the flight schedules and hardware requirements as a function of year. There are five tables in the group, an overall summary, NASA ETR, NASA WTR, DOD ETR and DOD WTR. These charts represent the data requested in NASA letter PD-TUG-P(028-74). The next chart shows the same flight requirements data in the format used by MDAC in the study. The final chart shows the usage of individual Tugs to accomplish the mission model. At the top of the chart, the number of flights per year is shown and the number of Tug expendable flights. The number of Tugs required were established by first determining the number of Tugs necessary to accomplish the 1990 requirements and working backward from that point.

#### CONFIGURATION OPTION 35

	REQUIRED	ACCOMPLISHED
DEPLOYMENTS RETRIEVALS	387 180	355 180
# ETR LAUNCHES # WTR LAUNCH # REFLIGHTS DUE TO LOSSES	1NITIAL 64 /35 4/6	51WAL 84/91 33/15
FLIGHT COMPOSITION  EXPENDABLES (E)  TUG WITH BURNER II (KS ₁ )  TUG WITH POLARIS (KS ₂ )  TUG (BASIC)  VEHICLE LOSSES/REFLIGHTS	- 10 95 1 (110)	219 3 (226)
FLEET SIZE REQUIREMENTS  FOR OPERATIONS  FOR RELIABILITY	<u>4</u>	7 3
TOTAL  REQUIREMENT AT IOC (MIN)  FLIGHTS PER ARTICLE	<u>5</u> 2 27.3	10 3 31.9

I 29.7

TURNAROUND CYCLE 32.3 DAYS LAUNCH TO LAUNCH ( CALENDAR DAYS)

FLIGHT SCHEDULE

7.4

TUG CONCEPT OPTION 3S

LAUNCH SITE ETR/WTR AGENCY NASA/DOD

COMPANY MDAC

	2	8	81	82	83	81	85	98	87	88	89	8	TOTAL
TUG (BASIC) **		ю	23	22	37	0† (2)	34	(1)	(1)	₹	(3)	(1) (8) 36 336	(8) 336
AUXILIARY STAGE				(2)	(2) (1) (2)	(2)		(3)	(3) (2)				(10)
DROP TANKS													0
(OTHER)	*1												1
SHUTTLE **	*	м	23	22	37	40. 34	İ	35	39	₹.	35	36	336

() DENOTES NUMBER EXPENDED.

REMARKS: 33 payloads not accommodated due to Shuttle limits of 3 Tug flight in 1980 and 21 in 1981

^{*} IVU test flights

^{**} Includes reflights due to Tug reliability

FLIGHT SCHEDULE

	NASA	
OPTION 3S	ETR AGENCY	MDAC
TUG CONCEPT	LAUNCH SITE E	COMPANY

	79	80	81	82	83	78	85	98	87	88	89	96	TOTAL
TUG (BASIC)		ж	7,7	12	15	(2) 18	15	(T)	(1)	12	(3)	(1)	(8) 148
AUXILIARY STAGE				(2)		(2)		(3)	(2)				(6)
DROP TANKS													0
(other)	1*												н
SHUTTLE	*1	3	14 12	12	15	18	15	14	16	12	16	13	149

() DENOTES NUMBER EXPENDED.

REMARKS: 13 payloads not accommodated due to Shuttle limit on Tug flights * IVU test flight

2-38

FLIGHT SCHEDULE

	DOD	
OPTION 3S	ETR AGENCY	MDAC
TUG CONCEPT	LAUNCH SITE	COMPANY

	79	80	81	82	83	48	85	98	87	88	89	96	TOTAL
			7	10	13	17	OH OH	12	15	15		<del></del>	126
1					(1)								(1)
													0
1													0
	†		7	10	13	17	01	12	15	15	10	17	126

REMARKS: 20 DOD flights not accommodated due to Shuttle limit on Tug flights () DENOTES NUMBER EXPENDED.

FLIGHT SCHEDULE

TUG CONCEPT OPTION 3S

LAUNCH SITE WIR AGENCY NASA

COMPANY MDAC

<del> </del>	<del></del>				
TOTAL	37	0	0	0	37
90	-7	1			4
89	5				5
88	77				4
87	9				9
98	4				#
85	9				9
84	77				4
83	7				7
82					
81					
80					
62					
	TUG (BASIC)	AUXILIARY STAGE	DROP TANKS	(отнек)	SHUTTLE

() DENOTES NUMBER EXPENDED.

REMARKS:

2 2

FLIGHT SCHEDULE

	DOD	
OPTION 3S	WTR AGENCY	MDAC
TUG CONCEPT	LAUNCH SITE	COMPANY

<del></del>					
TOTAT.	21	0	0	0	23
06	1				1
8	4				-=
88	2				a
87	N				~
98	5				5
85	2				2
18	-				-
83	4				7
82					
81					
80					
79					
	TUG (BASIC)	AUXILIARY STAGE	DROP TANKS	(OTHER)	SHUTTLE

() DENOTES NUMBER EXPENDED.

REMARKS:

FLIGHT REQUIREMENTS

# OPTION 3S

	80	81	82	83	84	85	98	87	88	89	06	TOTAL
ETR												
NASA	m	14	10	15	14	15	10	13	12	13	12	131
рор	ı	-	10	12	17	10	12	15	15	10	17	125
NASA EXPENDABLE	_	-	ı		2	1	П	н	ı	ю	1	8
NASA KICK STAGE	١		5	1	ય	1.	3	2				6
DOD KICK STAGE	ı			1								1
TOTAL	3	21	22	28	35	25	56	31	12	26	30	274
WTR												
NASA	ŀ	1	,	17	17	9	7	9	4	5	7	37
рор	ı	ı	ı	4	Н	2	5	5	2	4	н	27
TOTAL	0	0	0	8	5	8	6	8	9	6	5	58
REFLICHTS / LOSSES				7		н			7		-	7
											-	

EQUAL USAGE SCHEDULE

* . *

# OPTION 3S

		7	 												
TOTAL.	332	80	31	33	777	23	34	33	33	33	33	32	25		#
06	35									9	6	10	10		7
89	35	3					2	2	1	5	9	6	10		
88	33						2	2	м	9	5	10	5		1
87	39	7			,	9	ĸ	9	7	7	10	3			
98	35	7			ε	17	8	7	7	9	က				
85	33				5	1	6	6	6	3					1
84	017	5	3	3	3	2	10	10	6						
83	36		10	10	10	9									ı
82	22		7	6	2	7									
81	21		6	8	17										
80	3	స	2	1											
	NUMBER OF FLIGHTS	NUMBER OF EXPENDED TUGS	TUG ID 1	2	3	17	5	9	<b>L</b> -	80	6	10	11		RFFLIGHTS / LOSSES